EAGLE TALK

McDonnell Aircraft Company

MCDONNELL DOUGLAS

1 JANUARY 1984
VOLUME 1

RESTRICTION NOTICES

A History of the

F-15 EAGLE

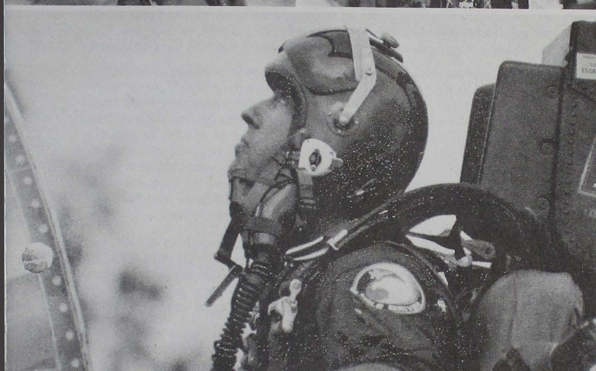
Volume 1

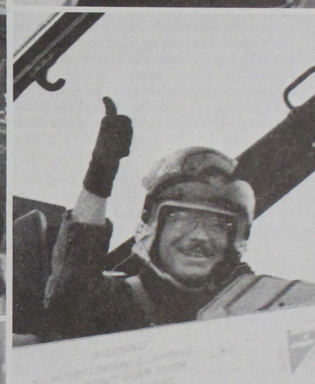
(REPRINTS FROM MCAIR PRODUCT SUPPORT DIGEST)

MCDONNELL DOUGLAS

Happiness is... being an Eagle Driver!

(Photographs taken during 1974 European tour of F-15.)





"EAGLE TALK"...a crewman's multi-volume history of the McDonnell F-15 airplane

(reprints from the MCAIR PRODUCT SUPPORT DIGEST)

The F-15 Eagle became operational on the 14th of November 1974, at Luke Air Force Base, Arizona. As of this point in time (1983), more than 800 F-15A, B, C, and D model aircraft have been produced for the air forces of the United States, Japan, Israel, and Saudi Arabia. Only speculation is possible regarding an ultimate number of aircraft and the Eagle's ultimate position in the history of aviation and the world, but its position thus far is both secure and spectacular. The McDonnell technical support publication — PRODUCT SUPPORT DIGEST — has documented this "progress of the Eagle" from the very beginning in articles and reports by flight test and engineering personnel. Prepared exclusively for our military customers, these articles offer both a fascinating, informal history of the F-15 program and contemporary technical discussions of aircrew techniques and procedures. Regardless of one's level of experience with or degree of exposure to the Eagle, information of the type published in PSD is worth reading and preserving. However, it is the nature of magazines to be temporary and disposable, to "disappear" in time with the consequent loss of valuable data to personnel newly assigned to our airplane. Therefore, as on previous aircraft such as the Demon, Voodoo, and Phantom, MCAIR preserves this hard-won expertise in the form of periodic collections of previously-printed articles. This is Volume I of the Eagle collection and is composed of general-interest material arranged in chronological order; if you are interested in how the F-15 got to where it is today — test programs, simulators, milestone events, etc., it's all here in this volume, in authoritative articles written by the pilots as they were performing the tests. Volume II contains the more technically-oriented aircrew articles, arranged by subject, from the past 10 years. Volumes III and up will be published as the accumulated information warrants.

There is a tremendous amount of information packed into these slender volumes of talk about Eagles, but there are two points to bear in mind when reading, one concerning the "currency" of the material; one its "applicability" —

- Articles published herein were up-to-date and valid technically as of the time of original publication (indicated in the table of contents and on each article). However, the F-15 Eagle as it is coming off the assembly line today contains many differences from the earlier (and earliest) configurations. Ship No. 1 and Ship No. XXX (latest to fly) may look alike on the outside but, from both system and operational standpoints, they are not alike. If you read something in these articles that does not resemble the cockpit or system as you know it today, please "check six" to see where the information is coming from — its date of publication. It would have been too difficult and time consuming on the part of our pilot/authors to review every past article for current validity (especially since some crewmen are no longer flying or are flying other airplanes). Therefore, we suggest you use these volumes for background and general information on aircraft systems, techniques, and procedures. EAGLE TALK contains a wealth of wise words, but only your DASH ONE is guaranteed to have the latest, and the official, ones. Which leads directly into the second point.

- Please be sure you understand the "type" of information provided in these volumes (and in the PRODUCT SUPPORT DIGEST from which they were reprinted) so you won't be looking for advice that isn't there and thus get disappointed. Our publications do not discuss F-15 "tactics." How to utilize the aircraft in combat is the subject of official military documentation; our only objective is to inform you about F-15 "capabilities." The theory behind this is that the more information you learn in our publications, the better you should be able to apply the information in yours.

Since this page deals with the "philosophy" behind EAGLE TALK and the PRODUCT SUPPORT DIGEST, it would be appropriate to end with a quote from an individual who has provided much of the information in both. In one of his articles on Eagle driving, Pat Henry, (current) MCAIR Chief Experimental Test Pilot, wrote. . . "As with most philosophical discussions, no decisions are made for you, so the monkey is still on your back to handle any given (soggy) situation. That's the responsibility that accompanies the pride of professional flying."

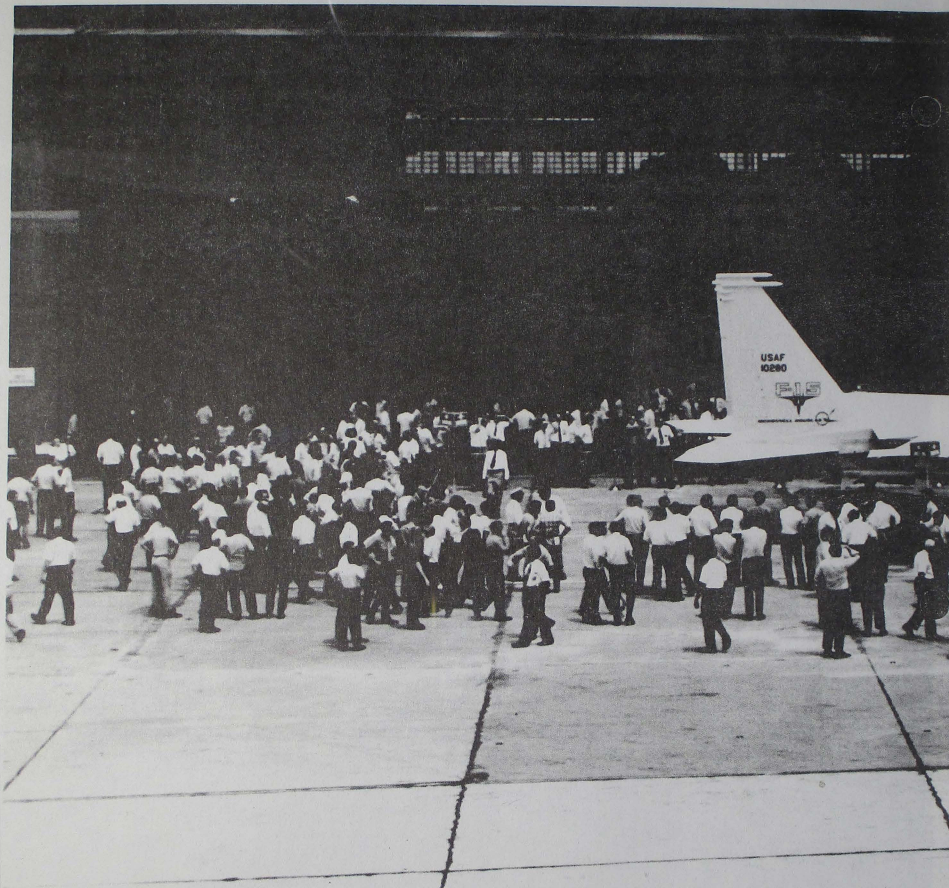
Thus, on behalf of the people at McDonnell Aircraft Company who have contributed to these publications, our wish is that, when the monkeys begin to climb up your back in some future (soggy) situation, you will recall some of the discussions herein and that all of your Eagle flying will be responsible, proud, and professional!

VOLUME I — TABLE OF CONTENTS

[A note to the reader - Text and photo originals for the articles published in this volume are no longer available, and all pages herein were reproduced from two-color printed copies. We hope you will be so pleased just to have the data that you will overlook the substandard visual appearance of much of the material.]

First Contract: 1 Jan 1970
First Flight: 27 July 1972

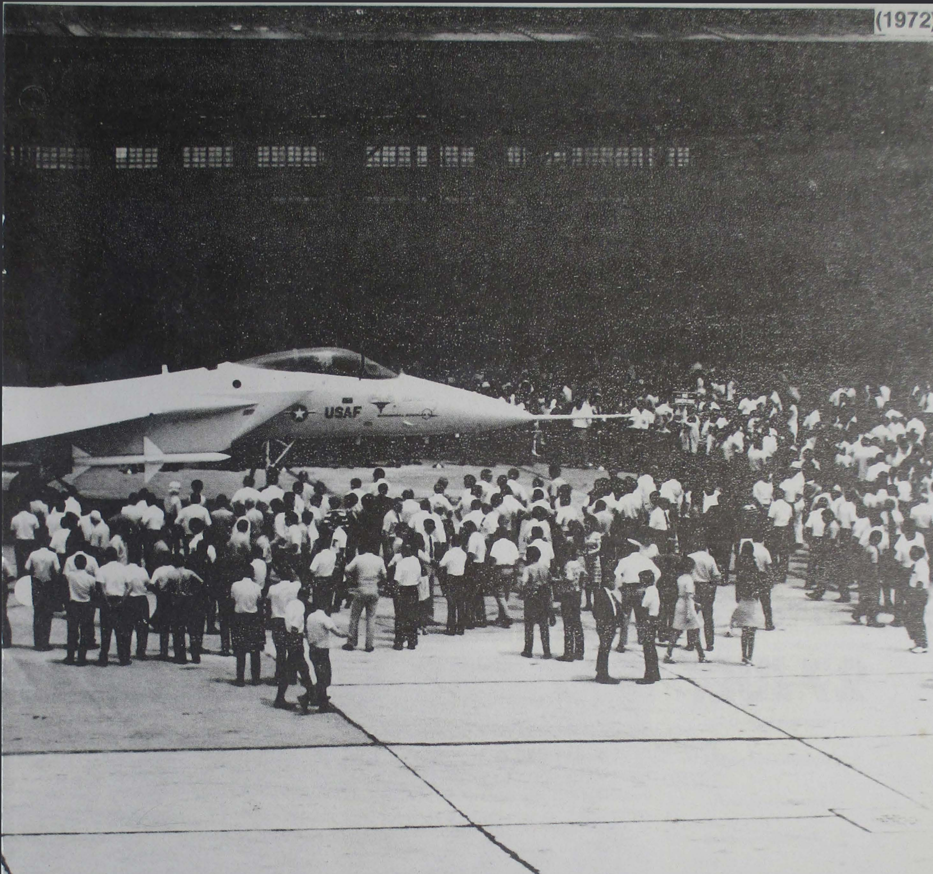
In the mid-sixties, when the USAF asked the aviation industry for the near impossible in combat aircraft capability, MCAIR embarked on an unprecedented development program from which the "EAGLE" evolved. Out of this program emerged the F-15 - an air supremacy fighter which can clear the skies of hostile aircraft at night or during the day, in fair or foul weather. Termed by those who use it as "the best yet," the F-15 is today, and will be for many years to come, the bulwark of the Free World. It first entered operational squadron use on 14 November 1974, and is now in service with several USAF Tactical Fighter units and the Israeli Air Force. Under license, Japan will build the Eagle for its Self Defence Forces; and in the early 1980s, the aircraft is scheduled for delivery to the Royal Saudi Air Force. The F-15 is still a young aircraft and has not reached its full maturity - in years to come, it is quite possible that what is now the world's most outstanding air supremacy fighter could also be filling other roles as an attack, interceptor, and reconnaissance aircraft. The Eagle, with its present capabilities and future potential, is a key national asset in which the men and women of McDonnell Aircraft Company take great pride. Its use by USAF and several foreign nations will help assure stability in the highly sensitive international environment in which the F-15 must operate in the foreseeable future. ■



26 JUNE 1972

EAGLE AT REST - USAF 10280, F-15 No. 1, poses quietly outside main manufacturing building after rollout ceremonies. No.'s 2, 3, and up are being fabricated on other side of hangar doors, on production lines adjacent to F-4 final assembly. (left)

(1972)



DAY OF THE EAGLE!

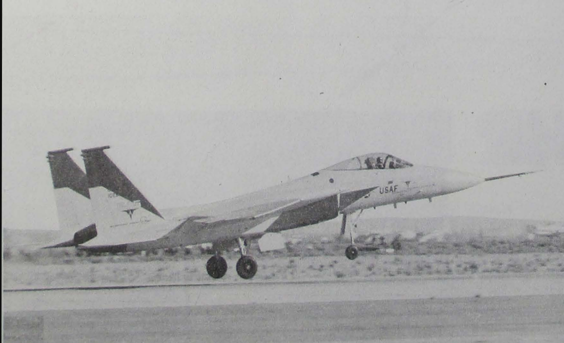
EAGLE AND ADMIRERS - Almost everybody in the company found reason to visit production ramp sometime during F-15 Rollout Day. Official ceremonies were held inside building, in background, before more than 1000 government, military, and civilian guests. (above)

EAGLE ARCHITECTS - General William Momyer, Commander of Tactical Air Command, and James McDonnell, Chairman of McDonnell Douglas Corporation, push throttles to mark start of rollout ceremonies. George Graff (left), President of McDonnell Aircraft Company, and Don Malvern, F-15 General Manager, look on approvingly. (right)

(1972)

27 JULY 1972 - THE EAGLE SOARS!

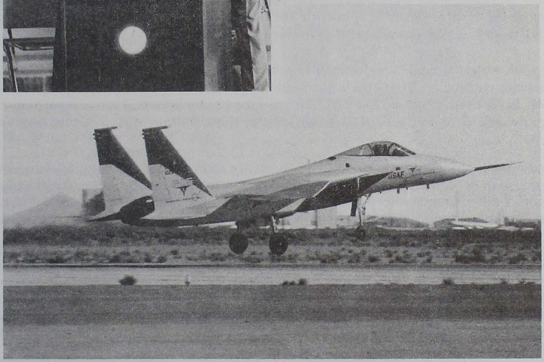
The grace of an Eagle. The F-15 is shown in a clean configuration during its highly successful first flight. (top) Concluding its first flight, the F-15 Eagle touches down at Edwards AFB, California. (bottom left) At the controls of the F-15 during its first flight was Irv Burrows, Chief Test Pilot of McDonnell Aircraft Company, and frequent contributor to the PRODUCT SUPPORT DIGEST "Ready Room". (bottom right)



Days of the EAGLE

(1974)

(TOP) 26 June 1972 – Gen William Momyer, then Commander of the Tactical Air Command, and McDonnell Douglas Chairman J.S. McDonnell push throttles signifying rollout of the first F-15 Eagle. (MIDDLE) 27 July 1972 – A month after rollout, with Chief Test Pilot Irv Burrows at the controls, the first of the Eagles begins its successful maiden flight. (BOTTOM) 14 November 1974 – Lt Col Ted Laudise, Commander of the 555th TFTS, Luke AFB, discusses the Eagle with President Ford as the first F-15 is received into Tactical Air Command inventory.



9/70
Preliminary design review

9/70
Radar contractor selected

4/71
Critical design review

6/71
Avionics review

6/72
1st airborne avionics performance

6/72
Major subassembly tests

7/72
FIRST FLIGHT

9/72
Bench avionics complete

9/72
1st Aircraft performance demonstration

12/72
1st airborne avionics performance

1/73
Fatigue test one lifetime

1/73
Static test 2 critical conditions

6/73
Armament ground test

8/73
One G flight envelope

12/73
Fatigue test 3 lifetimes

12/73
AF evaluation summary

3/74
Equipment qualified

3/74
CAT II A/C & equipment in place

8/74
External stores flutter release

10/74
Training equipment in place

10/74
Fatigue test 4 lifetimes

10/74
AGE equipment in place

11/74
CAT I flight tests complete

11/74
FIRST AIRCRAFT TO TAC

". . . The answer to this problem is an air superiority fighter built for one specific purpose - to clear the skies of enemy aircraft and with all design directed toward that one goal from the beginning. . . ."

(from NO GUTS – NO GLORY, by Major Fred Blesse, 1953)

F-15 Flight Test Report

By IRV BURROWS/*Director of Flight Test Operations-Field*

The Air Force quotation reproduced above is the last sentence from a now-classic article on aerial combat tactics, written some 20 years ago originally, but just published again in the most recent issue of USAF FIGHTER WEAPONS REVIEW (Nellis AFB). The "problem" Major Blesse (now Major GENERAL Frederick C. Blesse, DCS Operations at Hdq PACAF) was referring to concerned the inability of then current aircraft to provide the pilot with sufficient tactical capability for the competition. Here is our first DIGEST report on the answer to this problem – the USAF F-15 . . . the Eagle . . . THE air superiority fighter.

Written by the Eagle's first pilot, we are pleased to welcome Irv Burrows back to the magazine after a by-line absence equal to the time he has spent in the Eagle cockpit. Irv's last article was his description in June 1972 (as company Chief Experimental Test Pilot) of the slatted F-4E, in his terms "the best F-4 yet." Here in June 1973 is his initial status report (now as company Director of Flight Operations, Edwards AFB) on the F-15 – the airplane we think will turn out to be "the best yet."

When our editor decided it was high time to get a little F-15 information in this publication, I was faced with a dilemma: detailed discussions of the airplane performance per se are still rather sensitive unless we deal only in rather bland information which is not really much news to anyone. Techniques, handling problems, other information of the type we normally publish in the DIGEST are either not well enough established or, again, considered sensitive.

It occurred to me that perhaps information on the flight test program itself might be of interest. I find it's easy to get so wrapped up in our own business that we feel everyone must be aware of what's going on, when, in fact, if your day-to-day business is dropping bombs, shooting guns, ACM, etc., you may not be familiar with what we've been up to here at Edwards. So in hope that this will reach some interested eyes, here goes.

A flight test program structure is analogous to the building of a house, if one stretches the point a bit. There are certain things that must be accomplished before the airplane is ready for operational use just as the foundation, walls, roof, heating system, wiring, and plumbing must go into a house. Stability and control, handling qualities, engine responses and performance, structural integrity, and aero-elastic stability are major building blocks that have to be checked off before the basic airframe/engine is ready. Attendant systems investigations include heat and vent, avionics, missile/tank/weapon separation and jettison, gunfire, etc. A program which simply investigates all these things, and confirms the proper operation thereof involves many airplanes and many months.

Quite obviously, test programs are also designed to solve problems–so when a stability snag comes up, efforts are focused on fixes which in turn have to be evaluated, the net result of which can be an extension of that portion of the program. My point here is simply to explain that (contrary to the impression created by that terrific painting they used to introduce my story) the airplane does not come off the drawing board ready for action–nor is it just a routine drill to get it ready. It's a full fledged several-airplane and many-people effort –hectic at times, frustrating at times, busy and interesting *all* the time.

Our Number 1 airplane, which first flew last July, has carried most of the stability and control and handling qualities work. We used it to get our initial look at engine characteristics and to expand the speed/altitude/"G" envelope. We examined (and are still examining) such things as buffet levels at increasing AOA; stick forces during maneuvering; adverse or proverse yaw; pitch transients with gear, speed brake, and flap extension/retraction; external tank handling characteristics; etc. We are currently clearing the flutter envelope (assuring that none of the control surfaces will tend to vibrate to destruction at any speed/altitude point within the advertised envelope). Toward these ends we've expended some 200 flights on this bird.

Airplane 2 is designated our propulsion development vehicle. Engine transients (e.g. idle-MIL-idle) are examined under all conditions, as are A/B lights and shutdowns. The airstart envelope is being defined and, of course, the pilot techniques for handling these chores, which will go into the handbook, are an offshoot. Engine modifications or new engines (such as Series II vs Series I) are first evaluated in this airplane. We are now flying YF100 Series II's in

Airplane 2 while the others still have Series I's (this is roughly analogous to -17's and 15's in the F-4). As the only current test airplane with an operative AAR receptacle, this airplane was used for our first look at air-to-air refueling (a mission which was quite successful and which incidentally, produced our front cover photograph taken while we were somewhere over Beatty.)

Number 3's lot in life is the development of avionics systems. Radar and fire control are of primary interest here, but other important systems are heads up display, inertial navigation, TACAN/ILS, central computer, armament control, AHRS, and the interface of all of them.

These programs are of continuing nature–airborne systems don't get developed in a day or a week or a month. We think in terms of several months, or of years. So now, nine months into the program we've got a good start - no, make that an excellent start. But there's a long way to go. Airplanes 4 and 5 will be here at Edwards by the time this hits the news-stands–and so may Number 6. Their chores will be structural testing (confirmation that the airframe will hang together under maximum load conditions); initial weapons separation and gunfire; and automatic flight control system (auto-pilot) and missile fire control system respectively. Later on, Number 7 will get into the act with more weapons testing; Number 8 will initiate the stall/spin investigation; and Number 9 will demonstrate aircraft/engine performance. The first two-seater, TF No.1, is actually the eighth airplane to come off the line and should be flying late this summer. After some dual control evaluations, it will also get into the weapons separation business.

I hope maybe this has enlightened some of you who are remote to the flight test business. I know 20 years ago when I was driving F-80's around for Uncle Sam, I hadn't the foggiest notion what went on between design and operational deployment. One thing I have learned since then is that everything takes time – evaluation, development, fixes all take more time than we might expect. But for those of you who are looking forward to the production F-15 arrival, we're getting it ready as quickly as possible.

What you'll get will please you I'm sure. The Eagle has excellent visibility through the large one-piece windshield and big bubble canopy. You can see essentially 360° around the airplane in a level or up direction and downwards quite well through a good portion of the azimuth spectrum due to the outward bowing of the canopy. You sit up quite high–in fact, an initial impression is that

The Lucky "Ones." Colonel Wendell Shawler (left), Director of F-15 Joint Test Force at Edwards AFB, returns from becoming the first one in USAF to fly the F-15. Alongside is DIGEST author Irv Burrows, Director of McDonnell Flight Operations at EAFB, and the first one to fly the Eagle period.

you're awfully exposed–the canopy sill seems to be down around your hips! There is minimum clutter above the glare shield to block your view–only the heads up display bracketry is there.

The cockpit itself has had over two years of thoughtful concern during the design stages by the guys with maximum interest–pilots. The design engineers had considerable "help" from McDonnell and Air Force pilots and I only hope they haven't been too bent out of shape by our constant objections, suggestions, etc. I know the net result is a fine, workable cockpit of which the designer can be proud and in which the pilot can be happy.

The control system has been very pleasing and although we have not finished optimizing it, the general qualities are extremely attractive. The airplane is light to the touch, very responsive, and "feels like a fighter." Stall speed has not yet been totally defined but we have flown the airplane to some pretty low airspeeds and pretty high AOA's without encountering any objectionable characteristics. Maneuvering qualities in excess of anything flying were ordered by our customer; designed into the airplane; and in fact are showing up in real life. It's a genuine pleasure to suck the Eagle into a turn that leaves any chase airplane staggering around unable to hold either the G or the speed.

Approach speeds have corresponded closely with those predicted, being on the order of 135 to 140 KIAS. The airplane, being very lightly wing loaded, tends to respond to any gust disturbances and hence is not as "solid" as fighters with much higher wing loadings, but response to controls is plenty adequate to overcome this. The nose can be held high off the runway down to 50-60 knots which provides good aero braking; and all indications point to some pretty powerful brakes (program to fully evaluate them coming up) so short rollouts should be no problem.

Our in-commission rate has been truly gratifying. The Eagle is not a simple airplane–let's face it, the simple airplane is not built that can perform to the extremes of this maneuvering and speed envelope while providing the handling qualities, target acquisition and kill capability that this one does. And yet from the very first flight we've found that the airplane tends to keep on flying day after day. Routine inspection, weather (yes, even at Edwards), and design mods all eat into the flight schedule but we feel that even with the tender loving care our birds get, 15+ flights per month per airplane is outstanding. For purposes of comparison, the F-4 over its flight test history (some 15 years) has averaged eight.

Our maintenance folks and those of our customers (who have watched closely for problem areas) feel that the airplane will be a good one to work on. Sure, there are a lot of tough spots to get to and there are some design "Murphys." Hopefully, many of these will be improved upon before the F-15 hits the field. We think you Air Force guys charged with keeping that first wing of Eagles "up" will be pleasantly impressed with the ease of doing so.

That's enough for now. If this has been interesting for you, maybe I'll drop a few more Edwards ad libs your way as we go along. Then, before you know it, the airplane will be all yours and we'll be cranking out the Ready Room nuts and bolts a la F-4.

product support digest

(front cover) F-15 No. 8 will investigate high angle of attack characteristics - stall, spin susceptibility, etc. (back cover) VF-154 F-4's fly formation with 5th FIS F-106's over San Diego, California.

JOHN F. SUTHERLAND / Vice President, Product Support; THOMAS L. PLEIN/Director, Product Service; VERNON E. TEIG/ Director, Support Operations.

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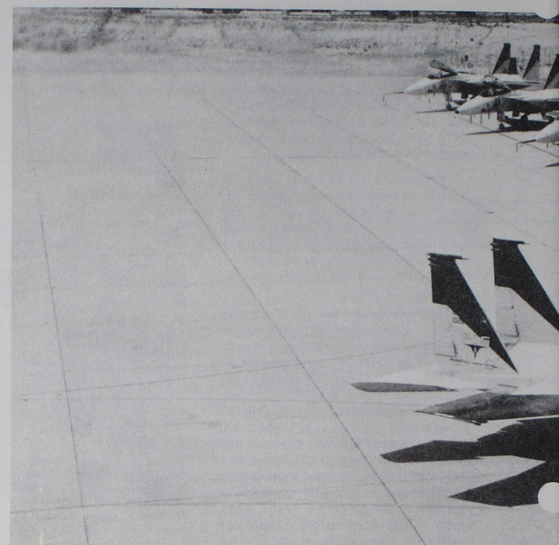
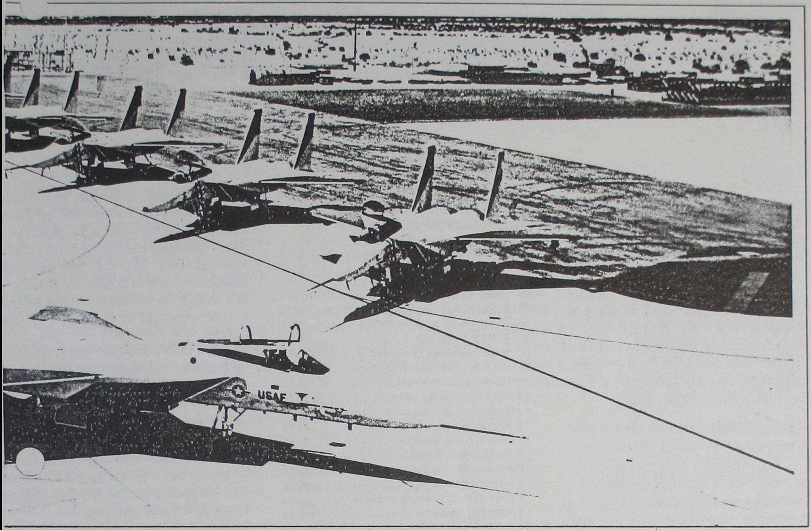
EAGLE TALK



Back in June of this year, F-15 Chief Test Pilot Irv Burrows introduced us to the Eagle in a summary of the flight test program underway at Edwards AFB. He concluded his report in the 2nd Quarter DIGEST with the promise to find time in that busy program to occasionally update the report. It took Irv six months, or two issues, to find that time and then only because we let him kill two birds with one stone (or rather, get two presentations from one set of data) - this report is extracted from speeches he and USAF Colonel Wendell Shawler gave in September to the 17th Annual Symposium of SETP (Society of Experimental Test Pilots) in Los Angeles.

The presentations, while originally aimed at a group of flight specialists with a particular concern for aircraft



F-15 Update

technology, are pertinent to everybody with an interest in the Eagle for events are described which occur at a critical period in the life of this airplane. The flight evaluation/demonstration period of a new aircraft is a particularly challenging and exciting time. It is the time of "hardware" - when theories are proved; when state-of-the-art becomes reality; when problems are encountered and solved; when changes in direction are negotiated; in sum, when the "wash is hung out on the line."

Irv's attention in his article is directed toward a few examples which demonstrate the importance of CAT I to the ultimate success of an airplane. And DIGEST readers have a real bonus in the companion presentation by Colonel Shawler, with the military point of view of the F-15 to date. Colonel Shawler is Director of the F-15 Joint Test Force at EAFB, and as such commands the AFFTC, TAC, and Training Command participation in the F-15 development program.

In this situation, we don't mind at all being scooped by SETP. Because unless you're an experimental test pilot yourself who happened to catch Irv and the Colonel in L.A., this will all be news to you, too . . . .

Progress Report

By IRV BURROWS/*Director of F-15 Test Operations*

The F-15 program has been a busy one since we last discussed it here. Among the highlights have been completion of five Air Force Preliminary Evaluations (which Colonel Shawler will elaborate on), and the first non-stop ferry from St. Louis to Edwards, when Jack Krings brought Airplane No. 7 out here on the 29th of June. I'll summarize our general status very briefly and then move on to a few more interesting subjects. Our current statistics look something like this:

FLIGHT TEST STATUS - THROUGH 31 OCTOBER 1973

(First Flight - 27 July 1972)

Number of Aircraft Flying	11
Number of Pilots (Company/Military)	10/10
Number of Flights	1010
Total Flight Hours	1010
Maximum Hours Per Single Flight (Unrefueled)	4
Maximum Mach Number	2.5+
Maximum Calibrated Speed - Knots	800
Minimum Calibrated Speed (Not Stalled)	104
Maximum Altitude - Feet	66,900
Maximum Load Factor - G's	6.3

I won't dwell too much on these numbers other than to mention that we've averaged close to 14 flights per airplane per month, including all downtime inspections, modifications, routine maintenance, etc. This is a considerable increase in flight rate per airplane over previous test programs.

Some other progress check points show equivalent compression - CAT II start on the F-15 is set for 20 months after first flight; on the F-4, it occurred at the 26th month. First squadron delivery for the F-15 is due 28 months after first flight; the F-4 took 31.

If you've never seen a "Demonstration Milestone" chart out there in the real world of squadron operations, here's the one we're working to by specification for the F-15:

1	Preliminary design review	9/70
2	Radar contractor selected	9/70
3	Critical design review	4/71
4	Avionics review	6/71
5	Major subassembly tests	6/72
6	Engine inlet compatability	3/72
7	FIRST FLIGHT	7/72
8	Bench avionics complete	9/72
9	1st A/C perf. demonstration	9/72
10	1st airborne avionics perf.	12/72
11	Fatigue test one lifetime	1/73
12	Static test 2 critical con.	1/73
13	Armament ground test	6/73
14	One G flight envelope	8/73
15	Fatigue test 3 lifetimes	12/73
16	AF evaluation summary	12/73
17	Equipment qualified	3/74
18	CAT II A/C & equip in place	3/74
19	Training equip in place	10/74
20	Fatigue test 4 lifetimes	10/74
21	Ext stores flutter release	8/74
22	AGE equipment in place	10/74
23	CAT I flight tests complete	11/74
24	FIRST AIRCRAFT TO TAC	11/74

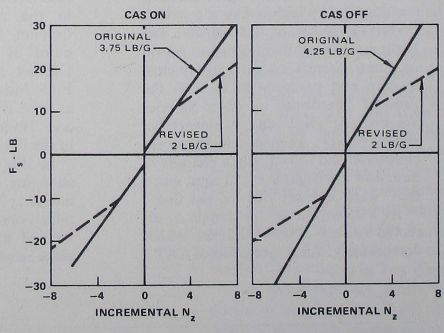
We're proud, of course, to indicate early or on-time completion of every milestone so far - the most recent one being the clearance of the 1 G flight envelope (No. 14). But that's enough statistics - now I'd like to discuss a few things we've been working on out here which might be of interest to you.

STICK FORCE PER G

Back in the simulator (pre-flying) days, we (both Air Force and McDonnell) discussed at length the F_s/G values and came to the conclusion that our airplane might not be as nimble as we'd like simply because of stick forces involved. Let's look at a plot of what was designed into the airplane (Figure 1) - a pattern chosen with the thought to provide forces comfortable for maneuvering but not low enough to aggravate high Q sensitivity or suggest a PIO.

(Continued on Page 12)

FIGURE 1 STICK FORCE PER G



Air Force Tests

By WENDELL H. SHAWLER, COLONEL, USAF/*Director F-15 Joint Test Force*

We have flown five Air Force Preliminary Evaluations (AFPEs) in the past year for a total of 51 flights. In addition to these AFPE flights, the Air Force has flown 37 participation flights for a total of 88 Air Force flights. Ten Air Force pilots have been involved, not including demonstration flights in the TF (two seater).

The first evaluation was conducted in September 1972 on F-1 with the primary purpose being handling qualities. However, since this was the first Air Force look the total aircraft/weapon system was evaluated. The second AFPE was completed on F-2 in January 1973 for performance and propulsion objectives. This was the first aircraft that had engines capable of developing rated thrust. The third evaluation conducted on F-3 gave us the first look at an all-up avionics system including the radar and head-up display. The next AFPE was on F-5 to evaluate the gun and the latest was another look at the avionics on F-6.

Before I get into some results of these AFPE's, I would like to outline our F-15 Joint Test Force (JTF) organization. The JTF includes AFSC, TAC, AFLC, and ATC. All of these Commands have had inputs to the F-15 Weapons System, and TAC pilots have been actively involved in the flying program. The members of the JTF represent all functional areas so that a complete evaluation can be made on all aspects. Further, the Air Force has access to all contractor data so that we can monitor progress, look for potential areas of difficulty, and most important eliminate to a large degree duplication of testing. We use contractor-acquired data in our reports and McDonnell uses our data routinely.

The F-15 program was designed with what I call a semi fly-before-you-buy system. Several major components have had competitive evaluations, including the engine, radar, and gun. Further, the test aircraft delivery schedule was slow enough to allow an extensive evaluation of the complete weapon system and make the necessary changes without impacting the first production aircraft to be delivered to the TAC (from first flight of the F-15 to first delivery to TAC will be 28 months). Finally, the F-15 program has a series of milestones throughout the development. With the exception of the engine qualification test, all milestones were completed on or ahead of schedule.

Let's look now at some results of these AFPEs, highlighting some of the good areas as well as problems and fixes that have been or will be incorporated.

PILOT CONSIDERATIONS

The handling qualities of the F-15 are excellent. It has a conventional hydromechanical system and a Control Augmentation System (CAS), either of which is capable of flying the aircraft. In the early evaluation the aircraft met the criteria of 8785B, however, a relatively new technique was used to determine handling qualities - air-to-air tracking of another aircraft. This technique showed some areas that could be refined to improve the tracking capability. As discussed by Irv, some minor changes were made primarily to the CAS that have taken an already good flying aircraft to an excellent handling fighter.

Two of the most important aspects of an air superiority aircraft are cockpit visibility and maneuverability. I consider the F-15 excellent in both categories. Cockpit visibility is really great. Maneuverability is best stated by a couple of representative numbers: the thrust-limited turning performance in military power at 10,000 feet is greater than six "G's". Can you imagine pulling more than six "G's" all day in military power? The thrust-limited turning performance in afterburning is the design limit of the aircraft in much of the envelope.

ENGINES

We have had good results with the flight test portion of the development. Some of the operating limitations early in the program were too restrictive, such as slow engine response during acceleration; afterburner light; and throttle transients.

- The slow engine response showed up basically in two ways: first in slow acceleration time from idle to military; and second in being unable to fly good formation or other maneuvers that required fast response.

Two basic parts of controlling the engine are the Unified Fuel Control (UFC) and the Electronic Engine Control (EEC). The UFC provides the basic fuel control and the EEC comes in just prior to military and controls all the engine parameters. The UFC was modified to give a much more rapid fuel flow buildup out of idle to provide increased torque to overcome the mass of the engine. As a result of this increased fuel flow, the temperature would increase too rapidly; consequently, the EEC was modified to cut back the fuel flow based upon the rate of rise of the temperature. As a result of these relatively simple changes, the acceleration time was reduced to less than one-half the original time.

- The afterburner light envelope was too restrictive in the upper left hand corner of the envelope. Many changes were made which gave us a significant improvement; however, I'll cover only two of the more important modifications.

The F-15 has a five segment afterburner range which was designed to give a very smooth transition between segments. This is practically a requirement on a fan engine. The main difficulties were usually too rich a mixture causing a light and blowout or too lean a mixture preventing the light at all. The system has a quick-fill capability for each spray ring that controls the light-off of each segment. The amount of fuel in each of these quick-fills was originally the same and remained the same at all altitudes and machs. It was found that at sea level there was insufficient fuel and that at altitude there was too much. Consequently, the valve controlling this input was modified through a barometric device to decrease the amount of fuel as altitude was increased. This change gave us the biggest increment of improvement.

The second change in our A/B system was to decrease total fuel flow in maximum A/B. The difficulty was too much fuel for the air flow and size of the A/B area combination. By reducing the total fuel flow about 4000 pounds/hour, we eliminated the blow-out difficulty at maximum A/B. As a side effect, we have equal or greater thrust for less fuel flow.

- The last item on the engine was limited throttle movement, also in the upper left hand corner of the envelope. The original concept was to keep idle RPM to a minimum at all altitudes, which caused the problem by allowing the RPM to be 65% at 40,000 feet. Two difficulties arose: failure to get the engine out of idle due to low flow; and slow throttle movement required to get an acceptable acceleration. This was easily corrected by what I'm sure you know is on practically all engines - an increased idle RPM as altitude is increased.

AVIONICS

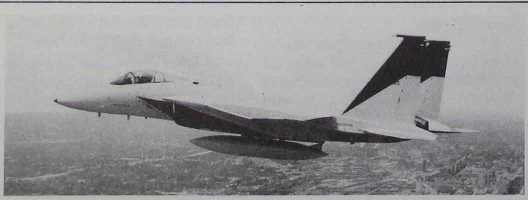
The avionics of the F-15 have progressed very smoothly, partially due to installing the complete system in a WB-66 prior to the F-15 ever flying. Consequently, when the Air Force flew the first evaluation the complete system operated very closely to design. The reliability was especially good for such a new system in that one radar set with its associated black boxes was used for the complete evaluation.

A unique feature of the radar is the synthetic display provided to the pilot. The raw returns are processed through the on-board computer and presented to the pilot in a clear, easily interpreted manner. This fact plus the design parameters have verified the one-man operability concept. In fact, one significant capability is to fly the complete mission with the head out of the cockpit utilizing the HUD, including an instrument landing.

An F-15 carrying the AIM-7F recently conducted a successful simulated missile launch against an Air Force/Lockheed SR-71 high-altitude, Mach 3 reconnaissance aircraft flying at near maximum speed and altitude. (The SR-71 has approximately half the radar cross-section of a Foxbat.) This capability, plus the short range missile (AIM-9) and the gun give the F-15 superiority over the present and projected threat into the 1980's.

MAINTENANCE

As mentioned earlier, the JTF has been evaluating the maintenance aspects of the F-15. The aircraft was designed for ease of maintenance and generally has been proven. Some items could be improved, such as sight gauge locations, type and location of access panels, and similar items. All of these will be changed prior to TAC receiving their first aircraft, thereby saving a costly retrofit program, and making the crew chief's job easier. ■



Progress Report

(Continued from Page 10)

To review just a moment - you'll recall that there is a hydro-mechanical control system which pretty well determines some basic control deflections and response values. This is considered the back-up system. The Control Augmentation System (CAS) operates over the mechanical system and modifies control surface deflections within its authority to provide aircraft response in line with stick position. The spring cartridge selected for the mechanical longitudinal system was relatively simple and provided a linear force gradient. Although there was some debate as to whether it was optimum, there was also reluctance to stir the pot too much at that point in time, based only on simulator experience. There was, of course, normal concern about potential overstress if the forces were lightened up too much. However, the wheels were put in motion to provide the engineering for a dual gradient longitudinal spring cartridge, after it was evaluated on the simulator and found to provide improved maneuvering forces.

Early flight tests revealed that our previous concern was justified - CAS OFF maneuvering forces were indeed too heavy for a fighter with the inherent capability of the F-15, and though CAS ON forces were significantly more comfortable because of the CAS contribution, there was still room for improvement. At an appropriate time in the program, the dual gradient cartridge was installed which provided the revised forces shown on the plot. CAS pitch computer modifications were required to produce a satisfactory match between CAS and the mechanical system.

First looks at the new system produced smiles from the drivers; and substantial flight testing since then has not uncovered any undesirable characteristics. Forces around neutral are quite comfortable to all speeds within the envelope; and there is no excess longitudinal sensitivity or trend toward PIO, either CAS ON or OFF. The slope change point cannot be felt as any inconsistency in maneuvering forces but the high G forces are tailored nicely.

The dual gradient spring is considered a production item and although they are slow in coming, we'll have all the airplanes so equipped eventually. The Eagle is now a one-handed airplane, even for those who want to spend 90% of each flight at 6 g's.

LATERAL SENSITIVITY

This was another control system problem which appeared on the simulator but was masked partially by lack of physiological cues. Design specs required some rolling accelerations well in excess of previous capabilities, which could only be achieved by creating a large amount of lateral control power and obtaining it quickly; i.e., lateral control surface deflections were sudden and big.

The $\pm 20^{\circ}$ ailerons are mechanical only, but differential stabilator is CAS controlled as well as mechanical, and it's a powerful force. Again, a linear stick to lateral control gradient was designed and incorporated. Normal, smooth maneuvering was comfortable, though highly responsive, but sudden small lateral stick inputs normally associated with formation flying, air-to-air refueling, and gun tracking resulted in an undesirable jerkiness - which, at higher Q's could approach a PIO tendency. A couple of ideas we're working with to fix this problem are:

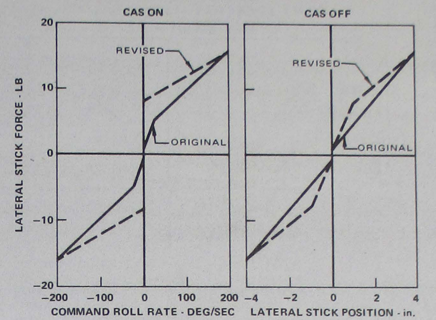
(1) Increased force gradient around neutral.

(2) A modification which provides logic to the CAS system to cancel out some of the roll rate commanded with small stick deflections.

The first amounts to a dual gradient force system as shown in Figure 2, coupled with a higher setting on the CAS transducer switches to prevent CAS from augmenting roll commands for small stick deflections. The second would simply tell the CAS to negate some of the roll rate asked for by small sharp stick deflections, thus attenuating the first motion response. Both of these approaches have merit, as perhaps do others.

(Note: Since this presentation in September, further progress has been made in this area, and we are zeroing in on what amounts to a dual gradient lateral system, both CAS ON and OFF.)

FIGURE 2 LATERAL CONTROL CHARACTERISTICS



LANDING GEAR

Let's discuss a subject now which I'm sure entered all your minds when you first saw the Eagle. How about crosswind landings with that narrow gear? Would you believe that a similar question occurred to many of us four years ago when the mockup was first viewed? Obviously, there were overriding considerations which drove the design to a narrow gear - weight being a critical one.

At any rate, the anticipated problem did appear and it went something like this: on a crosswind touchdown, several things would happen - the upwind wing would come up; the airplane wanted to weathervane into the wind; and it wanted to drift downwind. All of these characteristics were accentuated with the nose held up, so an early measure was to get the nose on the ground fast.

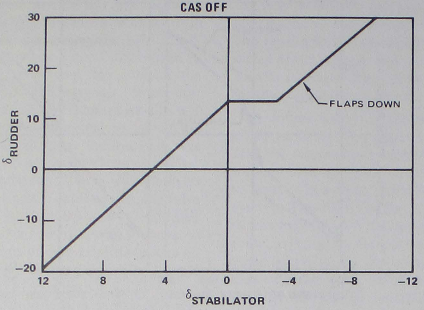
Examination of the situation quickly revealed a couple of causes:

- First, we had an aileron-rudder interconnect (ARI) system which said that as the stick was moved laterally (assuming it was longitudinally neutral or aft), rudder was produced in the same sense; i.e., if the right wing came up and the stick was moved to the right to counteract it, rudder motion would make the airplane yaw right - aggravating the normal weathervaning tendency (Figure 3).
- Second, with the stick aft, as it was if one wanted to hold the nose up, our system washed out some lateral control - this was designed into the controls to minimize lateral deflections at high angle of attack (Figure 4). It works quite well in the maneuvering arena. Rolling out on the runway, however, was not the place to reduce lateral control, particularly in a very lightly wing loaded fighter with a narrow gear.

The net result was that the wind would blow the wing up and start the airplane weathervaning. The normal pilot reaction moved the stick into the wind which did little or nothing to level the wings, but worsened the yaw into the wind condition. In this yawed condition with wing up, the airplane felt like it wanted to couple and the impression to the pilot was that the airplane was going to tip over on the forward downwind quarter. Getting the nose down made the situation somewhat tenable but all the unpleasant characteristics remained to a lesser degree and the resultant rollout was, in a word, uncomfortable.

The wing-up thing was further aggravated by main gear struts which tended to stroke at different times in the rollout, sometimes producing a 2 or 3 degree wing-down on a calm day until the up strut would stroke. Two or three degrees feels like a lot during

FIGURE 3 RUDDER DEFLECTION FOR FULL LATERAL STICK



rollout! One more weak point was the low gain nose gear steering. Our full time ±15° steering should have helped three-point directional control but the pedal vs wheel deflection relationship required long and strong legs to get much response.

A lot of effort has been expended to resolve this dilemma, but the solution is now in hand; the F-15 is quite satisfactory in 25-30 knot sidewinds. I'll trace the steps.

1. The ARI was essentially eliminated on touchdown. Since there is ARI inherent in both CAS ON and CAS OFF (mechanical) control systems, a pair of fixes were required to achieve this, but it was obvious from the outset that ARI had no place on the runway and had to go. The mechanical ARI was deactivated when wheel spin-up was achieved almost instantaneously after touchdown. This got rid of it during rollout, but retained it in a static condition so normal ground checks can be made. The input from the CAS ARI was essentially eliminated during rollout by biasing its reference AOA to 1° on either wheel spin-up or weight on wheels - at 1° AOA, rudder deflection with full lateral stick is close to zero.

2. Mechanical lateral control washout with aft stick was eliminated with gear down. Flight testing with the regained full lateral control did not reveal any deficiencies in the normal PA maneuvering envelope; and it became more and more apparent that more control was desirable not only after touchdown, but prior to. The additional CAS contribution was not required prior to touchdown, but was afterwards. Consequently, it was achieved by the same method used for the ARI - biasing its reference AOA to 1° regained full lateral CAS. These lateral control changes did wonders for the pilot's sense of well being - it's nice to be able to keep those wings level on the rollout!

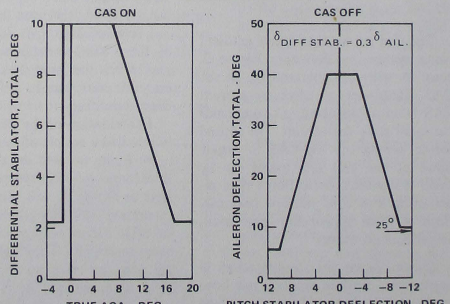
3. Nose gear steering gain was revised so that response was quicker. This was actually done to improve taxi qualities but the side benefit to directional control on the runway was quite obvious.

4. Main landing gear struts were significantly modified so that a large portion of the load stroke is achieved quickly on touchdown and the remainder at much lower speeds. This gave the airplane a much more solid feel after touchdown.

These modifications entailed considerable time and effort but will pay huge dividends. The airplane is now comfortable in significant crosswinds. Our technique is simply to touchdown in whatever crab is required, with wings level. Crab angles of up to 11°–12° have been used (at F-15 approach speeds, this computes to 25-30 knots crosswind component). The nose is held up to about 12° pitch angle for maximum aerodynamic braking and the airplane velocity vector is simply held straight down the runway with rudder until the nose is lowered at about 80 knots, at which point nose gear steering takes over.

Essentially the pilot "flies" the airplane down the runway using normal aerodynamic control until the nose is lowered. Brakes can certainly be used

FIGURE 4 LATERAL CONTROL AUTHORITY



during the two-point rollout to shorten the distance, but aero braking itself at $10^{o}-14^{o}$ pitch angle is quite powerful.

STORES

All missile separations and tank jettisons have been problem-free. AIM-7's have been fired from all fuselage stations and AIM-9's from the wing pylons under critical conditions with no adverse effects. External tanks have been jettisoned empty and full within a limited portion of the envelope and have separated cleanly.

Of interest here is the ball/socket retention point at the aft end of the tank and pylon which causes the tank to pivot nose down until an angle of 20^{o} is exceeded, at which point it can separate. This system essentially forces the tank to rotate nose down away from the airplane rather than allowing the forward portion to come up, letting the tank "fly."

Gunfire has been conducted throughout a fairly extensive flight regime including 1g points from 180 knots at 10K to 45K, 2.00 IMN at 40K, and at load factors up to 5.86 and high angles of attack. Gun gas stays well outboard and aft of the intake at all conditions. Our gas purging system has undergone a redesign for simplification and is effectively doing the job of a more complicated early design. As of this writing, some 25,000 rounds have been fired in the air from the M61 and no items of concern have cropped up. The 25 mm gun is still in the development cycle and airplane No. 5 may be fitted with it in the near future. ■

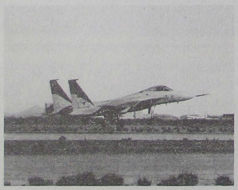
(1974)

The Eagle's Nest...

By DON STUCK/*Advanced Design Project Engineer*

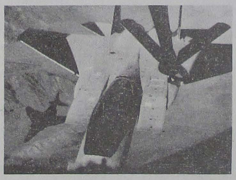
Just one year ago, Irv Burrows introduced us to the F-15 in the first operationally-oriented article on the CAT I flight test program then getting underway at Edwards AFB, California. If you've been following my own stories on the Eagle, you know that a lot of water has gone under the bridge and a lot of flight hours have gone into the F-15 logbook in the two short years since first flight. We thought you might be interested in a closer look at the first ten hard-working F's and TF # 1 -

Category I Eagles



#1
1st flight - 27 July 1972

Flying Qualities - evaluation of flying qualities and flight control systems. External stores and tanks flutter tested throughout the envelope.



#2
1st flight - 26 Sept 1972

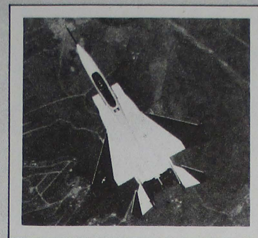
Propulsion Performance - total propulsion system compatibility from inlets to A/B's evaluated throughout the envelope. Missile launches accomplished to determine engine effects.

 # 3
1st flight - 4 Nov 1972

Avionics - evaluation of avionics and overall fire control system. Radar/weapon compatibility verification. Pitot static testing also assigned. This aircraft has successfully completed Category I programs and has been transferred to Category II.

#4
1st flight - 13 Jan 1973

Structural Integrity - flight loads and structural integrity with and without external stores. Aircraft was statically tested to 80% design limit load prior to inflight analysis. Landing gear loads and responses evaluated under normal and crosswind landings.



#5
1st flight - 7 March 1973

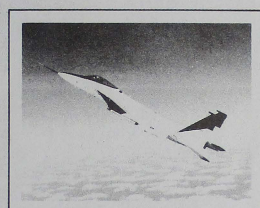
Armament # 1 - tank and weapons compatibility and jettison verification. 20mm cannon integration.

#6
1st flight - 23 May 1973

AFCS and Avionics - evaluation of AFCS and radar. Also # 2 avionics test bed and AIM-7F and AIM-9L fire control system testing. Communications, navigation, electrical, hydraulic, and secondary power systems were qualified on this aircraft.

#7
1st flight - 14 June 1973

Armament # 2 - tank and weapons jettison characteristics. AIM-7 firing to est effect on engines. Structural demonstration of missile and ECM pylons.



#8
1st flight - 25 Aug 1973

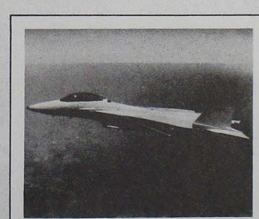
Spin - spin susceptibility and recovery procedures will be examined. Fuel system evaluation and qualification.

#9
1st flight - 2 Oct 1973

Aircraft/Engine Performance - propulsion system and performance prequalification. Engine environmental control system icing tests performed.

#10
1st flight - 16 Jan 1974

TEWS - Evaluation of the Tactical Electronic Warfare System and other electronic, radar, and avionic measurement and testing is being conducted at the Category I facility in Florida utilizing the Eglin Air Force Base range facilities.



(TF) #1
1st flight - 7 July 1973

Two Place Stability/Control/Performance - this first two-seat Eagle evaluated dual controls, performance, handling qualities, and all systems unique to the TF aircraft. Also to be used as trainer and test bed for advanced systems requiring second seat such as recce and interceptor versions.

product support digest

Eagle arrives at first official home - Luke AFB. (Air Force photos courtesy of base Information Division/Captain John Alexander; by TSgt Ed Goodhue, Sgt Brad McHargue, and Sgt Paul Smith. Back cover by McDonnell photographer Pat McManus.)

- *Cat I/II Status Report*
- *F-15 Arrives at Luke*
- *First One-Hundred*
- *Pilot Opinions*
- *Maintenance Aspects*
- *Product Support*
- *"Fast Pack" Program*

JOHN F. SUTHERLAND / Vice President, Product Support; THOMAS L. PLEIN/Director, Product Service; VERNON E. TEIG/ Director, Support Operations.

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VOLUME 21 4TH QUARTER 1974

NOT FOR PUBLIC RELEASE

"... Two big unknowns face the F-15. The first problem is whether the aircraft, in an operational configuration, will actually do all the good things that everyone hopes it will. Past experience has shown that most aircraft gain weight and lose performance as their development progresses from first flight to squadron use ..."

AIRSCOOP (United States Air Forces in Europe) Magazine/October 1972

USAF and DOD personnel around the world have shared AIRSCOOP's legitimate concern, as postulated over two years ago and shortly after the first flight of the Eagle. General historical experience with fighter aircraft has been exactly as stated, to the detriment of the mission and the unhappiness of the pilot. The F-15 entered operational squadron use on 14 November 1974 at Luke Air Force Base, Arizona. I invite your close attention to this special issue of our PRODUCT SUPPORT DIGEST, to see how those and other unknowns stand today.

GEORGE S. GRAFF/*President, McDonnell Aircraft Company*

G. S. Graff

CHUCK WITCHER

President Ford Introduces the Eagle

Text of Chief Executive's Speech at Luke AFB

This is the month of the pioneer in America. It is the month of the Mayflower and our earliest settlers. And this is the day of a new pioneer – a pioneer of the sky, of Peace – the F-15 fighter.

There were 102 passengers on the Mayflower when it crossed the Atlantic. The crossing from England to the new world took more than two months. And the end of the journey was freedom.

The F-15 can fly across the same Atlantic route today in a matter of hours. The purpose of its journey is still that of the Mayflower more than 350 years ago: freedom.

That is what really matters – the purpose of a journey. And I am here today to underscore to you and the world that this great aircraft was constructed by the American people in pursuit of peace. Our only aim – with all of this aircraft's new maneuverability, speed and power – is the defense of freedom.

I would rather walk a thousand miles for peace than have to take a single step toward war.

I am here today to congratulate you: The United States Air Force, McDonnell Douglas, Pratt & Whitney, all of the many contractors and workers who participated in this very, very successful effort – as well as the pilots who have so diligently flight-tested the F-15 "Eagle."

All of you certainly underline my feeling that we are still pilgrims on this earth and there is still a place for pioneers in America today. The challenges involving our country – here at home and abroad – we all recognize. But I am confident from the F-15 and your example here today that this is a nation of limitless horizons. There is no boundary to the energy, the ingenuity of the American people.

Frankly, that is why we will whip inflation, conquer our energy problems, and win the battle of the economy, to make a stable economy.

It is our job – in this last quarter of the 20th century – to prepare our

country for leadership in the 21st century. And we can do that by economic strength at home and by peaceful partnership abroad. These are my aims and my goals, and the goals of America now and in the future.

As I said in my Thanksgiving Day message which I made just a few days ago: "... let us pray for the courage, resourcefulness and sense of purpose we will need to continue America's saga of progress, and to be worthy heirs of the Pilgrim spirit. May we, too, find the strength and vision to leave behind us a better world, and an example that will inspire future generations to new accomplishments.

So I say to you, 'Congratulations,' those who had any part whatsoever in this great endeavor. It will serve the purpose of peace for a generation and more.

Mr. Mac, You Have a Great Airplane There!

Thursday, November 14, 1974, was a capstone day for many, many people and programs. More than 4000 organizations, from very small to very large, are supplying goods and services against DOD Contract F33657-70-C-0300. It was in partial fulfillment of that contract that TF-15A Serial Number USAF 73-108 was delivered to the Tactical Air Command at Luke AFB, Arizona on November 14, 1974.

In addition to his formal statement welcoming the Eagle into the Air Force, President Ford talked briefly with "Mr. Mac," also known as James S. McDonnell, Chairman of the Board of McDonnell Douglas Corporation. In their discussion, the President made the remark headlined above, and Mr. McDonnell accepted the compliment "on behalf of the thousands of skilled and creative people who developed the aircraft."

All of these people, Mr. Mac had noted in remarks made two years earlier at Eagle rollout ceremonies in St. Louis, "are lovers of peace . . . who know that, in the real world in which we now live, peace can be successfully waged only from a foundation of strength."

Thus President Ford, Mr. Mac, and the citizens both individuals are representative of, firmly believe that "this great aircraft was constructed by the American people in pursuit of peace. *Our only aim, with all of this aircraft's maneuverability, speed, and power, is the defense of freedom."* ■

(1974)

"... Our company and the pilots who have been instrumental in testing the airplane are proud to present you with what we firmly believe is the –

Finest Fighter Ever Built!

The quotation above and the title for this article are direct statements from Eagle Driver No. 1 – from McDonnell Chief Test Pilot Irv Burrows. We couldn't find a stronger statement, or in our opinion a more reliable spokesman, with which to open this "introduction to the Eagle" – our special issue of the DIGEST devoted exclusively to the US Air Force F-15 air superiority fighter.

However, there is one other quotation from an equally authoritative source that we'd like to present, from company Director of Flight Operations Joe Dobronski. Writing in the same pilot's introductory booklet from which Irv's statement was extracted, Joe said:

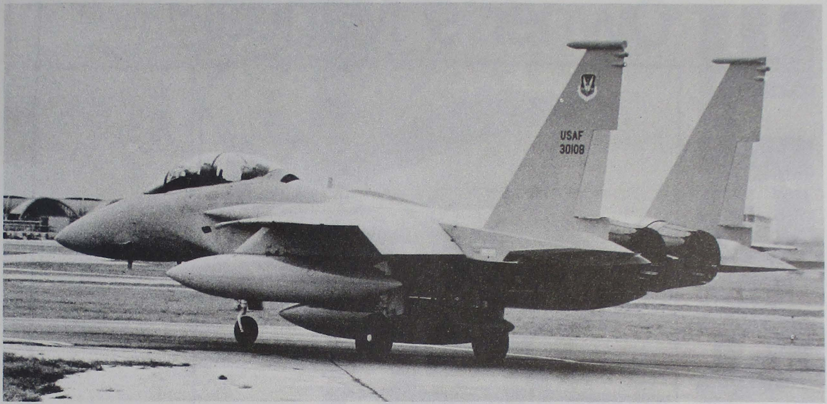
> "... I guess by now it will be apparent to you that all of us at McDonnell are pretty proud of this airplane! Once you get your hands on it, we think you will be too. ... "

That's what this special issue at this special time is all about – from a squadron operational standpoint, you are ready to get your hands on the F-15 for the first time. We want to tell you a little bit about this new airplane and to highlight what we think some of its features are from both flight and maintenance aspects, but our opinions really became academic on the 14th of November, 1974. It's officially your airplane now and you'll draw your own conclusions without any help from us.

McDonnell Aircraft Company intends to provide the same type of service and support for the F-15 that helped make the F-4 the bulwark of the Free World – our pilots; our field service representatives; our flight and product support divisions – our entire organization stands ready to serve. But from now on, it's really between you and the Eagle. We stand behind this product, but you sit inside it!

you've got yourselves an AIRPLANE! (1974)

By CHARLEY PLUMMER/*Experimental Test Pilot*



Number 21 Eagle off the production line was a TF (two-seater) destined to be the first production-configured airplane and the first for operational squadron use. TF-3 was delivered to the USAF on 14 November 1974 and stationed at Luke AFB, Arizona, as the first Eagle in the famed 555th Tactical Fighter (Training) Squadron. Known during the Vietnam conflict as "the largest distributor of Mig parts in Southeast Asia," Triple Nickel has given up its trusty Phantoms for this latest McDonnell product.

"Now," you might ask, "What's so special about the first production F-15?" I think the real point is what's *not* so special. Normally, you'd think that this airplane would be rather different from the test birds; after all, who ever heard of anything being nearly perfect the first time? Wait a minute now, before your skepticism shows too much - let me explain!

Sure, we've had some problems, but this airplane has all or virtually all the solutions to those problems in it. Yes, it does. Unbelievable? Maybe, but it's true. All of the basic discrepancies that have cropped up in two years of flight/ground testing have been fixed. TF-3 is ready! The big thing is that most of the airplane really was right the first time. Thus, the test birds and this one are probably closer in configuration than any fighter ever.

The only way to think about, talk about, or describe the Eagle is in superlatives. The airplane is a delight to fly; takeoff and landing a "piece of cake"; ACM is VSH; formation and refueling outstandingly easy; target acquisition and tracking capability excellent; and so on and on.

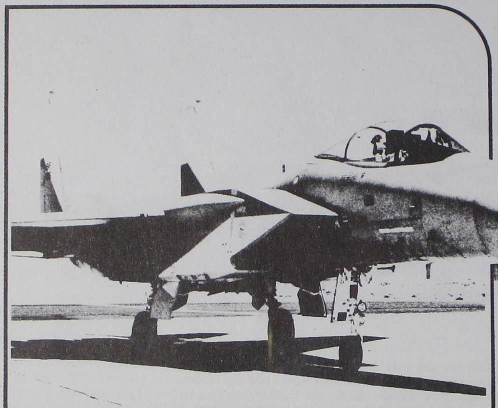
Although the airplane was designed for air superiority, it turns out to be an excellent (there's that superlative again) air-to-ground machine. Carries a pretty good load and dumps it where you say with accuracy better than anything you've seen yet, including those specialists in that A/G role. And beyond that, when you get done tearing up that ground target, you can whip up to wherever and take out any airborne opposition that might have had the poor judgment to challenge you. If they bother you in the middle of that A/G attack, just flip to GUNS mode in one easy stroke of the thumb and your systems are automatically ready - just swing around and hose 'em.

The 555th is receiving the most capable, maintainable, combat-ready first delivery ever. TF-3 is the visible result of the most successful, cost-effective fighter development program in aviation history. It's a fighter pilot's fighter without compromise, with global capabilities as a day fighter, night fighter, day attack, night attack, and all-weather interceptor. And the "fast pack" concept adds capability or potential for reconnaissance, ECM, extended combat air patrol, and many other modes that you can or might imagine.

As you have read elsewhere in this issue, the F-15 program personnel at McDonnell are proud of this airplane; we think it's the best fighter aircraft ever built and we'll stand behind it all the way. But you don't have to take somebody else's word for it anymore - you've got the first one now, and our St. Louis production line is busy cranking out more. To help you get acquainted with it, ask your local Field Service Rep for a copy of the little book described on the next page.

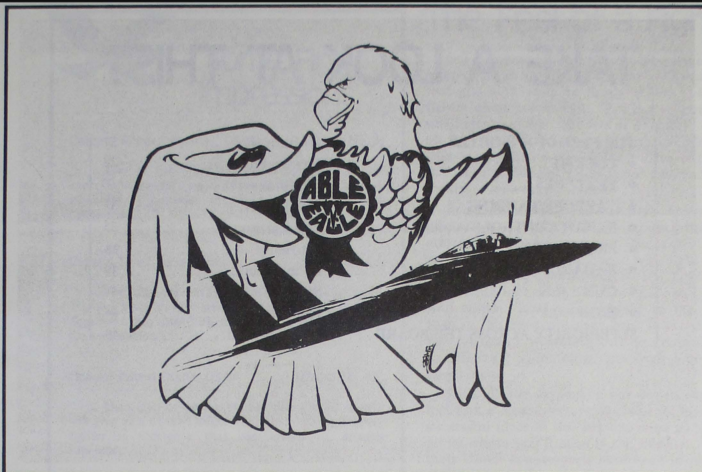
(1974)

EAGLE Owner's Manual



Your Introduction to the McDonnell F-15

[The "EAGLE OWNER'S MANUAL" was a pocket-sized booklet published late in 1974 to coincide with delivery of the first operational F-15 to the US Air Force. Because it was an excellent basic introductory look at the airplane, it is being reprinted in entirety here, except for the "key." The first 2500 copies came complete with a plastic "ignition key" for each new Eagle Owner. We don't know if anybody ever succeeded in starting up an F-15 with one.]



Air Superiority Fighter by McDonnell Aircraft Company

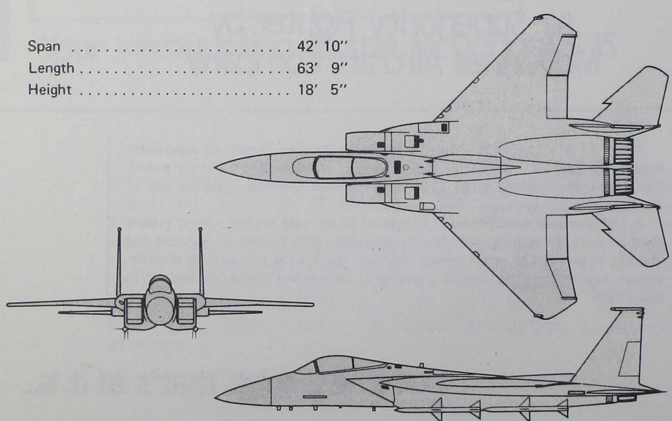
The F-15 is a single place, fixed wing, Mach 2+, twin fanjet, air superiority fighter. Its tactical missions are fighter sweep, escort, and combat air patrol. The F-15 combines the latest fire control system with an optimum mix of missiles and a multiple-barrel, high speed cannon.

A highly maneuverable combat fighter with low wing loading, thrust greater than its take-off weight, and an advanced electronic system to sort out and identify targets and to evade enemy defenses, the F-15 is able to find, identify, engage, and destroy any aircraft expected to be a threat during the late 1970s and 1980s.

but if you think that's all it is...

TAKE A LOOK AT THIS!

Span	42′ 10″
Length	63′ 9″
Height	18′ 5″



Some First Impressions

Colonel Wendell Shawler, USAF (Driver No. 3)

". . . Two of the most important aspects of an air-superiority aircraft are cockpit visibility and maneuverability. I consider the F-15 excellent in both categories. . . ."

Captain Don Carson, USAF (Driver No. 40)

". . . The total weapon system of the F-15 – airframe, engines, avionics – is designed for the fighter pilot. Together, they make up the finest fighter the USAF has ever owned. . . ."

General Robert Dixon, USAF (Driver No. 45)

". . . There can be no doubt that this aircraft system will give us a distinct edge. There is no air superiority fighter in existence that can match its combat capability. . . ."

The Feel of a Fighter

Our company and the pilots who have been instrumental in testing the airplane are proud to present you with what we firmly believe is the finest fighter aircraft ever built. The Eagle, though not a small airplane, has "the feel of a fighter" - it is fun to fly. Its performance and maneuverability surpass any operational airplane today, but perhaps the Eagle's strongest point is the tremendous capability of its weapon system.

From the beginning, company engineers and pilots have worked together to produce a maximum armament delivery capability. The result is an awesomely effective system, one in which the pilot can use the radar to LOOK FOR/DETECT/ACQUIRE/FIRE without taking hands off stick and throttles. And within visual range, thanks to the Head Up Display, he need not even look into the cockpit. Air-to-Ground weaponry can be pre-programmed to eliminate switchology problems when in the target area.

With all due respect to our design engineers, I feel that a large measure of credit for many of the successful ideas in this airplane must go to the test pilots whom you'll meet in this booklet. They and their USAF counterparts have been involved since design conception, especially in general cockpit layout improvements - the radio is easier to get at, engine instruments feature digital readouts, fuel gaging of all individual tanks (including externals) is available; and overall housekeeping procedures are greatly simplified.

But now comes your chance to "check us out" - to see for yourself if everything we say about this airplane is really true! You'll find that the Eagle has its own set of characteristics, techniques, and procedures, most of which are well covered in the flight handbook. Our intent in this "Owner's Manual" is to provide some less formal guidance and touch on a few of the more interesting facets of the airplane.

You're going to enjoy a rather steep learning curve when you first settle into the F-15 because it's easy to fly and the basic use of the weapon system comes on pretty quickly. But efficient use of all the capability this machine offers you will be a function of continual learning and practice. Your instructors and our pilots are ready to help at any time, but in the final analysis, it's up to you. Believe me, the results of a strong effort will amaze you!

We hope you'll use the information in this booklet as a stepping stone to familiarity. If you have questions which aren't covered here or in the -1, call us (collect) and we'll get you an answer quick. Our number is (314) 232-2142.

IRV BURROWS/Chief Test Pilot
(Eagle Driver No. 1)

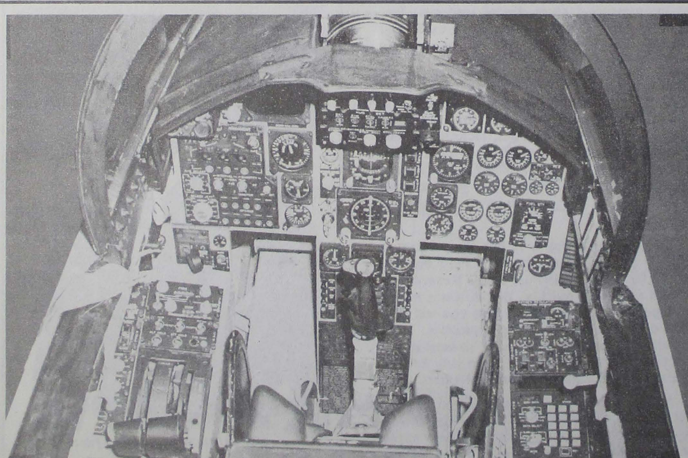
CHARLEY PLUMMER/Experimental Test Pilot
(Eagle Driver No. 12)

Cockpit

The Eagle was designed as a one-man, air-superiority fighter. To that end, the location of controls, visibility, and control capability have been tailored with you, the pilot, in mind. Many innovations have been incorporated, both in hardware and philosophy, and thus far the cockpit has been very well received by all who have been in it. We think you will find it easy to use and a pleasant place to do business.

Initial cockpit checks before climbing in are minimal. Whether you use the aircraft boarding ladder or the external ladder, the basic procedures are the same – prior to entering the cockpit, be sure the initiator warning device on the aft bulkhead is not extended; the canopy initiator interlock lanyard is connected; and the seat arming device is safetied (head knocker down). Strapping into the Escapac IC ejection seat is simple and straightforward; no leg restraints are required.

Your first impression after climbing in will quite likely be one of vulnerability. You'll find the canopy sill a handy elbow rest since it's about waist-high! The feeling of sitting "outside the airplane" goes away after a while, but this great visibility does take some getting used to. Be pre-



pared for a "falling out" sensation on your first turn out of traffic!

Now that you are installed, let's start back on the left side and look at equipment. For openers, nothing that must be used in flight is behind your elbows. Ground power switches and the BIT (Built-In Test) panels are located outboard. The Central Computer (CC) switch is also there and must be selected ON by the pilot. Inboard are the aux receiver (manual and preset) panel and various volume controls for intercom and other miscellaneous tones.

Moving forward, the exterior lights control panel is directly behind the throttles (we've been out there on those black nights too). Controls include a rotary switch for the formation strip lighting which can vary the strips from full bright to practically nothing and turn them off at the last bit of travel. Red beacon flashers are controlled ON or OFF by a toggle switch; and the normal exterior running lights are controlled by a rotary switch on the inboard side of the panel. Full counter-clockwise is OFF, with brightness levels increasing clockwise from very dim to bright. Several detents are provided to allow quick settings but the switch can be set anywhere in or between the detents to get the lights "just right." Further rotation continues to increase brightness up to the bright/steady detent; turning past that point into the next detent provides bright flash. No more hands off the stick fumbling for the right switch!

Outboard of the throttle quadrant and exterior lights panel are the IFF/AAI panels and radar control panel. The radar panel has manual or auto modes. On the forward portion of the left console is the fuel control panel – used only to stop external transfer or open the refueling door. Fuel transfer is normally completely automatic, including external tanks. The flap switch and rudder trim switch are on the aft portion of the throttle quadrant.

The throttles are unique – much of the weapons control system is built right into them! The outboard throttle carries the chaff switch, antenna elevation wheel, and gun sight reticle stiffen; the inboard carries the target designator control (TDC) and IFF interrogate switch on the forward face and the mic button, speed brake control, weapons select switch, and spare switch on the inboard side. Sounds like a lot, but it makes pilot use of the weapons system simple. (It also sounds like an afterthought, from what you've just read, but the throttles also control the engines!)

The target designator control is a force controller used to designate radar targets on the VSD or visual targets through the HUD. Pressure from one finger will operate it and you can write your name on the scope with it. The weapons select switch selects medium or short range missile or gun modes. The philosophy is MRM forward position, SRM intermediate position, gun in the aft or closest position. Selection of the guns position overrides any other A/A or A/G mode selected. The entire weapons system, including the HUD and VSD, is affected and set up for a gun attack. The MRM or SRM modes will not override A/G or Nav modes of the HUD; however, cycling to gun and then to SRM or MRM will put you in an A/A missile attack mode. The gun mode thus acts as an A/A selection mode. Note that the A/A configuration is always available at the flick of one conveniently located switch.

Forward of the throttle quadrant are the CAS and autopilot switches and the TACAN and ILS control panels. They are on the left side so you can hang onto the stick while you switch. All of the Comm/Nav switches in the aircraft are designed to achieve the full range of frequency or dial settings within one 360° turn of the knob. This makes for very rapid channel or frequency selection.

Outboard of the nav panels are the ramp switches, roll ratio switch, and anti-skid control switch. The left quarter panel contains the landing gear handle, flap indicator, tail-hook switch, and pitch ratio indicator and switch.

The left side of the main instrument panel is mainly taken up by the armament control panel (ACS), which displays the status of all weaponry on board, all external stores such as tanks and bombs, and the various methods of delivery selected. Through this panel, the pilot can pre-program the delivery methods he wishes for several different stores prior to flight. Upon reaching his launch site, he merely selects the appropriate program and has at it. Most programs are A/G. The A/A are automatic as previously mentioned.

Above the ACS panel is the fire warning system. This is more than just warning lights. A single, one-shot, three-way fire extinguishing bottle operates into either engine compartment or the AMAD/JFS system (aircraft mounted accessory drive/jet fuel starter). The panel has three light-buttons - for left and right engines and AMAD/JFS. A flashing light grabs your attention to an overheat condition; if the light turns steady, it means a fire - push the button to arm the problem system and flip the DISCHARGE switch. About seven pounds of a pressurized evaporative gas discharge into the compartment of the last system armed. Since pushing an engine fire warning button closes the main fuel shutoff valve to that engine, you'll have to push again to reset the system if you desire to restart. The system can be tested by the TEST position of the discharge switch, which turns on all three lights.

The VSD, radar scope, ANMI (or whatever you prefer to call it) is to the right of the fire warning system. It contains the brightness and contrast controls, but since the display is synthetic and not raw video, no gain control. Tuning is as simple as with a good TV set. Auto mode will provide constant contrast under varying light conditions through a light sensor on the face.

Basic flight instruments appear to be standard; however, there are some differences. Airspeed and altitude are digitally driven from the CADC/CC system. No uncorrected information is available to these instruments. In the event you need pure pitot static, it's available on the standby instruments on the center console. The ADI/HSI are standard instruments with command steering and raw ILS glide slope on the ADI; basic range, bearing, and ILS azimuth info on the HSI.

Three square buttons to the right of the ADI provide mode control for the entire weapons system. If any button is depressed, it will light up to display the mode selected. Four modes are available (one of which results if none of the three buttons are selected): air-to-ground (A/G), navigation (ADI), vis-ident (VI), and air-to-air (no lights on). The air-to-air mode can be selected to override any other mode by moving the throttle-mounted weapons select switch to GUNS. Selection of any of the modes automatically provides the HUD and weapons system with the correct symbology for that mode.

The ADI mode provides all navigation, attitude heading, and steering information in the HUD. The HUD, we feel, has become the primary flight instrument for basic flying as well as combat. Everything you need except engine performance is there. A unique feature you may not have seen before is the velocity vector (VV). This symbol is representative of the actual flight path vector of the aircraft. The ILS command steering is flown against the VV, thus providing a picture of the actual touchdown point as well as space position command. The other modes provide aircraft flight info data in the HUD as well as weapons steering.

One of the best features of the cockpit is the location of the main UHF and IFF controls. They are directly in front of you at glare shield level and are set up for fast reaction. Comm channel select (manual or preset) is rapid, and the IFF ident switch is simply a button. Just jab. Again, you can hang onto the stick on the wing in night weather while keeping up with channel changes etc. It's a new world!

On the right side of the main instrument panel you'll find the hydraulic gauges, engine instruments, and fuel indicators. The engine instruments all have digital readout plus a needle, except the oil pressure gauges and nozzle indicators which are needle only (most people never notice the needle on the combination gauges). Fuel flow indicator readings include A/B fuel flow when A/B is on. The oil pressure and hydraulic gauges are about the size of a quarter but are easily read.

The fuel gauge indicates total fuel in and on the aircraft, including external fuel. A dial indicates total internal fuel while a digital counter provides total fuel on board. In addition, two other digital counters are provided to indicate fuel in feed tanks, tank 1, internal wings, or individual external tanks as selected. A spring-loaded BIT position runs all indications to a predetermined point to check the gauge.

Let's look now at one of the real innovations in this airplane - the engine start system. No external power is required - engine start is accomplished through the Jet Fuel Starter (JFS) system. The JFS switch is on the engine control panel on the right console; the JFS handle is located below the fuel gauge. Placing the JFS switch to ON; then pulling the handle straight aft provides hydraulic accumulator power for JFS start. If the JFS does not start, the handle can be rotated 45° and pulled again to provide another bottle to the JFS.

Once the JFS is running, a small generator provides power for the ICS and the engine master switches. When the master switches are on, momentarily lifting the finger lift on the appropriate throttle will engage the JFS to the AMAD which will rotate the engine. Throttle to idle then provides ignition. The aircraft emergency generator will come on when the engaged engine reaches about 15% - 20%, thus providing power to the engine instruments among other things. The JFS automatically disengages when the engine reaches 45 - 50% RPM and automatically shuts off after the second engine is started.

To the right of the JFS handle is the caution lights panel. Most of these lights will turn on the master caution (M/C) light located up there next to the IFF/Comm panel. Pushing the M/C light will turn it off and arm it for the next caution panel light which comes on. Two lights on the caution panel refer you to the BIT panel on the left console. These are the avionics BIT and the hydraulics lights. Status lights on the BIT panel will give you more specific information on those systems.

The right console contains several items of interest. Right forward inboard is the oxygen panel and the emergency vent handle. Next aft is the engine control panel which includes the engine master switches, generator switches, emergency generator switch, engine supervisory control switches, JFS switch and ready light, and external power switch. External power can be applied but is not necessary. (By the way, the aircraft has no battery.) Although this may sound like a busy panel, it is generally only used before start-up and after shut-down.

Outboard is the environmental control system panel. In addition to the usual controls, a switch is provided to select bleed air from either engine or both. Cooling air at 80°F is provided continuously (out of ports located on the left and right sides of the windshield) over the interior windshield and canopy. Cooling air also is ported through adjustable louvers in front of the stick. The air is dry and we have had no problems with a normal system in terms of frosting or fogging on descent from high altitude. Thus no special procedures are required to ensure good visibility. The flow is also sufficient to adequately cool the cockpit without fogging on the ground with the canopy closed.

The INS control panel is aft of the engine panel and is a keyboard with digital light readouts. Entries are made quite easily and quickly, even in turbulence. The INS/Central Computer combination provides a wealth of information and a great potential for future benefits. INS destination and steering info are displayed on the HUD, ADI, and HSI.

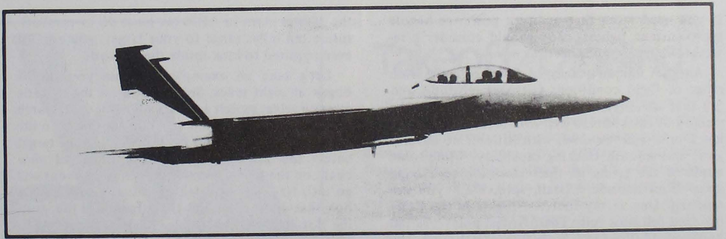
Outboard of the INS panel is the interior lighting control panel. The lights are blue-white, not red and are very effective. Seven separate controls provide lighting levels and matching capability to satisfy the most nit-picking night fighter.

TEWS controls and compass controller are aft of the INS panel. The TEWS scope is on the upper right portion of the main instrument panel above the engine instruments. Last but not least at the aft end of the console is a gigantic (by most fighter standards) map and data case which includes a thermos bottle fixture.

The canopy control handle is located under the right canopy sill and moves fore and aft to provide hydraulic power to lower, lock, unlock, and raise the canopy. The canopy lowers and then moves forward about one inch or so to lock. The canopy light will remain on until this has occurred and the canopy handle is swung under the sill and stowed.

The control stick is also part of the weapons system. The usual weapons release buttons and trigger are provided. In addition, the usual air refueling disconnect also has fore and aft positions spring-loaded to neutral. Forward selects boresight mode of the radar, aft selects supersearch, depressing the switch rejects radar lock and provides return to search or refueling boom disconnect when appropriate.

The paddle switch provides autopilot disconnect and nose gear steering disengage. NG steering has two modes - a full time ±15° steering mode and a maneuvering mode up to ±45° selected by the bottom push button on the control stick. Depressing the paddle switch on the ground will



disconnect the full time steering. Maneuvering steering is only engaged when its button is held in.

Emergency brakes and nose gear steering are provided through a handle to the left of the HSI on the main instrument panel. When this handle is pulled, emergency brakes and steering including maneuvering steering are provided. One note here - full time emergency NG steering cannot be disconnected by the paddle switch. The emergency brake/steering handle can be pulled and the system used even with normal power available. To reset, simply push in.

This has been a very cursory look at a rather complex cockpit, and you'll need the handbook to really do it justice. But though it is complex to discuss, it is great to use. Visibility is a standout; look over your shoulder at the view - no one's hidden at six o'clock in this machine, but then, there's no way he'll be there unless you invite him.

A last point - all of my discussion has been with respect to the single-seat Eagle. Sometimes this airplane comes with two holes. The front seat is the same in both versions, but when you drop into the back seat of a TF-15, you'll find about half of the instrumentation and something less than total operational capability - you can do most of the essentials from back there, but many of the niceties have been deleted. It's a fine ride in either seat - have fun and good hunting!

BILL BRINKS/Project Experimental Pilot
(Eagle Driver No. 19)

Features

The F-15, since it's a brand new airplane, is unique in itself, and that's the reason for all the other writeups in this little book. However, there are some outstanding aspects that don't fall directly under any of the categories covered elsewhere, and I'd like to comment on a few of them for you here. (Incidentally, talking about features, if your experience is for the most part in Phantoms, pay especially close attention to our propulsion and avionics discussions -- those two systems vary significantly from the F-4, and are loaded with "features.")

The F-15 mission emphasizes air combat, which drove the airplane design to high thrust-to-weight and low wing loading. This has interesting implications when fighting higher wing loading aircraft like the F-4. It means that an F-15 at the same gross weight and thrust setting as an F-4 could be pulling the same load factor ('g') at a significantly lower angle of attack (and therefore, lower drag). The excess power (P_S) due to this effect alone means that the F-15 could take F-4 engines that are degraded significantly in thrust and still be equal to the F-4 in P_S. The F-15 engine, of course, has over 25% more thrust than the F-4, so the net increase in excess power borders on the spectacular.

If you need more than military power to handle most current fighters, you should consider a refresher course in ACM tactics.

Another unique quality of the F-15 is the wide range of flight conditions (airspeed, altitude, and 'g') that the airplane handles very well. From the vicinity of 100 knots to well over Mach 2, the Eagle has a crisp roll response, with little or no adverse yaw, and smooth tracking capability. While some airplanes are giving all their attention to staying away from departure (stall, spin, etc.), you are tracking. One of my first test flights in the Eagle involved full stick rolls. The first test point was 180 knots at 45,000 feet! With full lateral stick, the roll rate was about 150 degrees per second (that would be the yaw rate in a similar maneuver in some other aircraft I know), and the maximum sideslip was about three degrees (hardly noticeable).

The integrated digital avionics system provides some really outstanding features; this fantastic collection of boxes can tell you everything you need to know except when to come down for lunch! The entire avionics system is conditioned by the Central Computer (CC), with conditioning initiated by the particular mission task you command. The philosophy, briefly, is this – you can command all air-to-air displays with hands on the stick and throttle. This includes launching or firing all the munitions, provided you fly around with the Master Arm in ARM (as most do in combat). Inside ten miles range to your target, you are not even required to look inside the cockpit.

Let's take an example. Suppose you spot a bogey at eight miles. Select MRM on the throttle weapon select switch and actuate radar supersearch on the stick as you turn to place the target in the Head-Up Display (HUD) field of view. As the target enters the 20 degree supersearch field of view circle on the HUD, you'll notice that the radar will go into track as indicated by a two degree square box that appears around the target. Pull the steering dot into the Allowable Steering Error (ASE)

circle on the HUD and pickle. I would emphasize that this is a 360 degree aspect capability against your target and is limited only by the swiftness with which you turn toward your target. If you leave the HUD camera in "Trigger" mode, the camera will automatically document your kill. Don't hesitate to let your opponent have a few seconds of air combat against that 500 pound bullet before you do. The very least you'll get out of it is a definite psychological advantage. I have personally knocked the wing off a maneuvering drone using this technique and would recommend it very highly.

Several of the electrical and hydraulic systems deserve honorable mention – full-time nose gear steering, continuous avionics built-in test, and anti-skid spin-up protection are all definite improvements – but let's concentrate here on some of the new features of the hydraulics system. The F-15 contains the standard PC 1, PC 2, and Utility hydraulic systems, but what's inside those systems is definitely un-standard! PC 1 and 2 each have two "circuits" (A and B); the Utility has three – A, B, and Non-RLS. "RLS" and "RPS" are two new acronyms born with the Eagle; they mean Reservoir Level Sensing and Return Pressure Sensing and they also mean a degree of hydraulic self-check and reliability previously unattainable.

Reservoir Level Sensing is an automatic method of isolating a leaking portion (circuit) of a hydraulic system while retaining the non-leaking circuit. As hydraulic fluid is depleted in the system, "A" circuit shuts off first. If the leak continues, "B" circuit shuts off and "A" circuit is turned back on. If the leak is in the Utility Non-RLS circuit, all the fluid will be depleted in the Utility system (the non-RLS circuit is generally reserved for back-up flight control functions, which you would not want to have shut off). The only pilot action associated with failure of any circuit is with a utility "A" failure; pilot action required is extension of the emergency landing gear.

Return Pressure Sensing was required because some of the hydraulic circuits can be switched into another circuit in the event of a pump failure. This effectively allows you to fly the aircraft with only one hydraulic pump operating. The RPS function pressurizes a failed circuit with 200 psi initially and checks for return pressure. If there is no return pressure, that means there is probably a leak and the good circuit will not be allowed to pressurize the leaky circuit. A hydraulic circuit breaker will pop on the reservoir, and that circuit will be denied any more fluid. The way you may come into contact with this feature initially is on start up when the speed brake won't move or one of the ramps won't function. Have the crew chief check the button on the reservoir and reset it.

PETE PILCHER/Experimental Test Pilot
(Eagle Driver No. 14)

Takeoff/Landing

F-15 takeoff and landing characteristics make it a piece of cake to get the Eagle off and on the ground. However, the piloting techniques are enough different from other airplanes you have flown in the landing pattern that it's worthwhile to talk about the Eagle's handling during these events.

TAKEOFF

Eagle takeoff can be either fairly routine or startling, depending on whether you use military power or afterburner. Military power provides more than adequate takeoff performance for a clean Eagle, whereas a max A/B thrust level makes a max gross weight takeoff more comfortable and provides a better rate of climb after T.O. in the event of a single-engine climb. In most cases, the pilot gets to decide what thrust level he needs to make the takeoff.

Obviously, Eagles check their motors and go through the Before Takeoff checklist before flying. On the runway I usually go to military power and check the engines, then release the brakes (which will hold the bird except on cool days at low altitude). If a burner takeoff is planned, select A/B and check the nozzles for a proper light off. The airplane is easily guided straight down the runway with the rudder pedals. It's hard for the pilot to determine whether he's using nose gear steering or rudders for directional control – but it doesn't matter anyway because the pilot action is straightforward and simple – just steer with your feet.

I normally start to rotate to takeoff attitude (10-12 degrees) at about 100 knots, and the Eagle is usually airborne at about 145 depending on gross weight and thrust, of course. There are no surprises on gear and flap retraction and if you forget the flaps, they will blow up at about 240 knots.

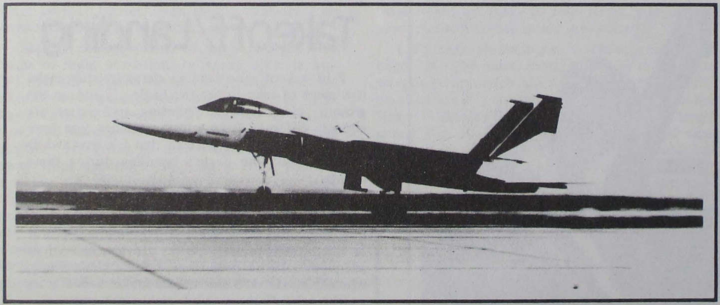
The next big event to watch for is the pitch ratio, which will start moving off the peg (1.0) somewhere between 225 and 300 indicated. This is an important check as the Eagle will be sensitive in pitch at high speeds if the pitch ratio fails at maximum authority (1.0). We think a climb schedule of 350 knots to 0.88 Mach is close to optimum, once you are up and away. For crosswind takeoffs, I feel more comfortable holding the airplane on the runway until flight is assured upon rotation (~145 knots for a clean machine).

That's all there is to it! What could possibly go wrong? You might overrotate and scrape the tail boom or engine feathers at about 16 degrees nose up; no one has done it yet, but I guess it could be accomplished. Directional control type problems normally associated with engine failures or tire/brake problems seem to be a no-sweat operation for the Eagle. As we said before, just keep it straight with the rudder pedals and brake as necessary.

A no-flap takeoff in the Eagle is quite like a flaps down one. Noticeable differences include slightly longer takeoff roll and higher takeoff speeds (about 10 knots), but otherwise the airplane feels much the same flaps up or down for takeoff.

LANDING

Pattern Entry – The pattern from initial to break can be comfortably flown at most any airspeed from 250 knots and up; I prefer 300 to 350 indicated. The break to downwind leg in this airplane is interestingly different. Namely, if you really wrap it up in the break, you'll find yourself on downwind about 10 feet from the runway which makes the turn to final very interesting. So if you do turn hard at the break, you'll need a cross-country to get to a reasonable downwind position. The rest of the break is normal – slow down the thrust and put out the drag. You can use the velocity vector on the HUD to make a very level turn. The gear can be lowered below 300 KIAS and the flaps below 240 KIAS. It's best to keep the speed brake out throughout the approach so that it's easier to handle the thrust that's available in this beast.



Landing Pattern – For the landing pattern itself, I like to come off the 180 position with about 180-200 knots and decelerate to an on-speed angle of attack (21 units AOA) by the base position, then fly 21 units until flare for touchdown.

Final approach is easy to control. The machine has honest speed/power and handling characteristics in that it's easy to stay on speed and easy to make glide slope and lineup corrections. The wings-level crab is best for crosswinds primarily because you'll need to stay in that crab during the landing rollout to keep it straight down the runway. The velocity vector on the HUD can be used to aim for a touchdown point on the runway. Flare to stop that sink rate for touchdown, please! The landing gear are cleared to 10 feet per second (600 feet per minute on the vertical speed indicator (VSI), but this is an impractical way to plant the Eagle since it will bounce back into the air if you have much sink rate. You should pull the throttles to idle during the flare or you may cruise in ground effect forever.

Landing Rollout – The landing rollout in the Eagle is different than most. There are a number of ways to slow the airplane for turnoff. You can aerodynamically brake, wheel brake, or combine the two to bring the machine to a slow pace. The airplane will aerodynamically brake down to approximately 65 knots on landing rollout if you pull the nose up and hold it there. It will want to fly if you pull the nose up too quickly above 100 knots, so you have to play this by feel. I like to use about 13 degrees of nose up pitch to slow the airplane on the runway. You can drag the tail booms or the engine exhaust feathers at about 15 to 16 degrees; we know – it's been done more than once. The aircraft symbol (w) on the HUD can be used as a good reference, and it flashes at 13-1/2 degrees airplane nose up in the landing configuration to provide warning of an excessive nose up during rollout.

If wheel brakes are used in conjunction with aerodynamic braking, the nose will fall through earlier. There is one trap that should be noted here as it could bite the unwary traveler. It goes like this: If you are wheel braking with the airplane nose up and release the wheel brakes without changing the longitudinal stick position, the nose will tend to rise even more – treat this one with care.

Wheel braking is simple with anti-skid on and slightly more demanding should the anti-skid fail. Maximum anti-skid braking is very effective and provides a good stopping technique for short field landings. Just lower the nose to the runway and mash the brake pedals. The stopping distance can be shortened even more by holding some back stick to keep as much weight on the rear wheels as possible. This is another of these play it by ear techniques that can be practiced.

Crosswind landings are also different in the Eagle. As we said before, the wings level crab should be used for crosswind landings and the pilot will need to hold that crab during landing rollout to keep the airplane tracking straight down the runway. Obviously, the amount of crab needed will change as you slow down. The pilot action required is easy – keep the wings level with lateral stick and keep the airplane tracking down the runway with the rudder pedals. The main landing gear tires will scrub and wear more in high crosswind landings, but you've got plenty of plies to handle the wear problem.

Flaps-up landings require more airspeed in the pattern and for landing, so it's best to fly a wider pattern from the 180° degree position. Expect longer rollouts after landing also. The only other difference is that the airplane will exhibit a bit more buffet if flown on speed (21 units) during the approach, and final approach speed will be 10-13 knots higher.

PETE GARRISON/Chief Experimental Test Pilot (Eagle Driver No. 2)

Flight Controls

The philosophy of the Eagle design was primarily, "Let's get the performance, then we'll tame it." The "taming" has been an exercise in flight control wizardry which burned a lot of midnight oil, but has produced for your pleasure a fighter with explosive performance that handles like a dream. However, under all that finery dwells a rather caustic personality which is cloaked in the shroud of acronyms such as CSBPC (Control Stick Boost and Pitch Compensator), PRCA (Pitch and Roll Control Assembly), and PTC (Pitch Trim Compensator).

I'm going to assume that you've had some basic exposure to the F-15 flight control system and know that it uses conventional hydro-mechanical ailerons and differential stabilator for roll control, collective stabilator for pitch control, and a rudder on each vertical for yaw control. In addition, there is a dual-channel, high-authority, three-axis CAS (Control Augmentation System) superimposed on the hydro-mechanical system. The CAS is utilized to shape aircraft response to pilot inputs, as well as provide three-axis damping and autopilot functions. The CAS can also provide aircraft control in the event of a mechanical system failure.

With this in mind, I'd like to break the control system into two elements – the basic hydro-mechanical system and the electronic system (CAS) – then further subdivide each and perhaps give you some insight as to why things are as they are.

BASIC HYDRO-MECHANICAL CONTROL SYSTEM

Pitch Ratio – This device adjusts the amount of collective (pitch) stabilator deflection available for a given longitudinal stick motion. The ratio is scheduled to produce essentially the same stick travel per "g" throughout the flight envelope. Since the longitudinal feel system is just a simple spring cartridge, this then relates to a constant stick force per "g" (Fs/g) (about 4.25 lb/g). It is scheduled by Mach number and altitude and does a rather good job; however, it won't quite cover the full range of aircraft and stabilator power and there is some scatter of the Fs/g, i.e., some mild increase in sensitivity during low altitude/high speed flight, and some decrease in sensitivity at low speeds.

Pitch Trim Compensator (PTC) – Obviously, the airplane can be disturbed in pitch in several ways – speed brakes, transonic trim changes, flap extension, etc., so the PTC system was devised to relieve the pilot of the task of compensating for these things with large longitudinal stick motions. In reality, it is an automatic series trim which senses that the pilot is beginning to compensate for a change in trim. Remember, the Eagle flys at essentially a constant stick position for a given g. If that stick position changes and the aircraft is not responding with the correct g schedule at 4.25 lb/g, the PTC will move the stabilator in the direction to maintain the g schedule. This is also true at 1 g and any disturbance from 1 g which the pilot begins to compensate for will automatically be trimmed to maintain 1 g. Since it is a "series" trim, the stick won't move perceptibly, but the stabilator will. It will continue to move to the limits of the PTC authority so long as the error signal between the stick position and the aircraft g schedule exists. Another fall-out of this system then becomes obvious – as you change speeds, there is no requirement to trim the aircraft in pitch – voila! "neutral speed stability" (at least with the gear up). It's going to be new to some of you, but I predict you're going to like it. No more frantically trying to keep up with trim during an A/B acceleration. On the subject of trim, the stick grip trim feels absolutely conventional. It simply puts a bias in the system, and it is not trimmed out by the PTC. If you're one of those strong armed nuts who likes to fly around with a bag full of force on the stick 'ala Thunderbirds, be our guest. It works fine!

Roll Ratio Changer – The roll ratio changer is simply an effort to accomplish in roll what we do in pitch, i.e., maintain the initial roll response of the aircraft somewhat constant. We use both ailerons and differential stabilator for hydro-mechanical roll control, and would generate some unacceptably high rolling accelerations, roll rates, and structural loads at high speed if we didn't back off the amount of roll control surface available with a given lateral stick command. Even with the use of the roll ratio, the max roll rate of the Eagle scatters quite a bit; however, the time to bank to 90° stays together pretty well.

Aileron/Rudder Interconnect (ARI) – Most pilots have excellent instinctive response to pitch and roll, but stupid feet. When the lateral acceleration has you pasted on the canopy rail, everyone has a pet "memory cue" to rely on, like "step on the hard rudder," "squeeze the ball in the middle," etc. That may have been okay for "flying the hump," but it just won't do anymore in the fighter business. We spent an awful lot of time trying to convince Hun and Phantom pilots that nature had intended that any maneuvering at high angles of attack must be done with the feet, but even then it didn't always work. The ARI "beasty" in the F-15 in an attempt to cure the "stupid feet syndrome" and put some logic back into "stick back, nose up" and "stick right, roll right"! The business of stick right-yaw left has made many a fearless fighter pilot pale. During rolling maneuvers, the F-15 has its share of adverse yaw at positive angles of attack and proverse yaw at negative angles of attack (primarily in the subsonic area, so the hydro-mechanical ARI is cut out during supersonic flight). Therefore, we simply utilize the roll ratio changer to wash out the yaw producing differential controls at aft or forward stick positions and produce rudder in the direction of the roll at positive (aft stick) angles of attack and against the roll at negative (forward stick) angles of attack. This is done to keep the adverse yaw from killing the roll rate at positive angles and prevent the proverse yaw from producing extremely high roll rates at negative angle of attack. Remember, the F-15 has strong positive dihedral effect, which produces strong roll in the direction of yaw at all flight conditions.

The full ARI is fine for the clean configuration; however, in the landing configuration, it's not so swift, particularly during the landing rollout with the stick held aft and attempting to put down that rising upwind wing. All that would be accomplished would be very little lateral control and a hard rudder into the wind. Take it from me, it's uncomfortable - so - on gear extension, we eliminate the lateral control washout with longitudinal stick position but retain the rudder deflection with lateral stick. On touchdown, we also eliminate the rudder deflection with lateral stick. In other words, on the runway, we go back to a conventional relationship of stick/rudder pedal to control surface.

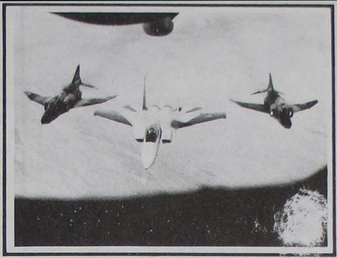
Rudder Authority – The F-15 has three different hydro-mechanical rudder authorities:

- $\pm 15^{\circ}$ for pilot input below 1.5 Mach number
- $\pm 5^{\circ}$ for pilot input above 1.5 Mach number (rudder pedal travel is limited)
- $\pm 30^{\circ}$ for ARI input with the stick held full aft and full lateral inputs made

The reason – high positive dihedral effect accompanied by very high rudder power generates too much roll due to yaw to allow the pilot the full 30° of rudder on the pedals. Steady-state, full-rudder sideslips would be impossible to control even though the rudder will not fully deflect as speed increases due to aerodynamic loads. However, the full 30° is required to handle the adverse yaw situation at some extremely high angle of attack flight conditions.

CONTROL AUGMENTATION SYSTEM (CAS)

The F-15 CAS utilizes series authority in all three axes. This simply means that the primary surface actuators contain an electronically controlled input to the actuator which can move the surface without pilot control stick motion. Although the CAS cannot move the actuator full stroke, the authority available can produce very



large control surface motion. Consequently, a hardover could cause out-of-control or structural failure. Since the pilot's capability to respond to this high authority is limited by his reaction time, the system contains an "automatic paddle switch" in the form of dual channels. Two completely redundant channels are constantly compared to each other, and in the event of a failure of one channel, the entire axis shuts down.

Pitch Channel – The pitch CAS channel detects a pilot pitch force command on the stick and converts this into an electrical command at approximately 3.75 lb/g. As the aircraft begins to respond, g and pitch rate "feed back" against the command signal so as to maintain a given Fs/g and damping characteristic. The hydro-mechanical system is continuing to function as previously described even though the series actuator is fine-tuning the pitch handling qualities through the CAS. The prime interface between the pitch CAS and pitch hydro-mechanical is through the CAS interconnect servo which drives the PTC in the direction to keep the CAS series servo centered in its $\pm 10^{\circ}$ stabilator pitch authority. The pitch CAS also incorporates a washout signal with angle of attack, so that the pitch series servo won't try to hold the stabilator up to the limit of its series authority during stall approaches. By washing out the pitch CAS at high angles of attack, the stick forces and aircraft motion look the same pitch CAS on or off – i.e. – the nose gets heavy at the same speeds because the CAS cannot deliver the extra 10° of CAS stabilator authority as would be dictated if the washout was not used.

Roll Channel – The roll CAS channel attempts to fine-tune the roll performance. Pilot lateral stick motion results in the hydro-mechanical differential stabilator and ailerons deflecting and at the same time, the lateral force on the stick results in an electrical roll rate command signal. The roll CAS attempts to satisfy the command through the series CAS authority of the differential stabilator (no CAS series authority on ailerons). In addition, roll damping is provided through the same series authority. The max CAS roll rate command is reduced above 1.5 Mach number to reduce the maximum roll rates at high supersonic speeds.

Yaw Channel – The yaw CAS series servo authority provides yaw damping, which needs no further explanation, plus a couple of other items which do – i.e. – CAS ARI and turn coordination. The CAS ARI does essentially the same job as the hydro-mechanical ARI except that it is scheduled by roll rate as a function of angle of attack. It can operate subsonically or supersonically if required, to keep the aircraft coordinated during rolling maneuvers. It attempts to keep the lateral acceleration as close to zero as possible. Since it has a series authority of $\pm 15^{\circ}$ of rudder, it can add this 15° to the 15° available to the pilot through the mechanical linkage when on the ground (no feed back). In the air, the feed-back loops will prevent the pilot from getting much more than the 15° hydro-mechanical deflection unless it's required to maintain zero side slip due to some aerodynamic asymmetry such as split flap, asymmetric external stores, etc.

I hope this has cast some light on the why's of the Eagle's flight control system. Happily, it comes together quickly after you start to fly, so relax and enjoy it!

PAT HENRY / Project Experimental Pilot
(Eagle Driver No. 4)

Propulsion

Since all of you have been, or will be, exposed to ground school and the pilot's handbook, a general knowledge of the engine and associated propulsion systems will be assumed. Therefore, except to say that the Eagle propulsion system consists of the basic engine (sometimes referred to as the "core" or "gas generator"), low pressure compressor (fan), afterburner, Jet Fuel Starter (JFS), and Air Inlet System, I'll skip the usual general description and concentrate on operational characteristics.

For openers, let's talk about ground starts. When making unassisted starts (no external power), you should have reasonably good ICS communications with the crew chief once the JFS is running. After engaging the JFS to the first engine, it is important to wait until the emergency generator comes on the line (approximately 18% RPM) before bringing the throttle to idle. Emergency generator operation is confirmed in two ways: EMERG GEN ON warning light on the telepanel (it should be the only light on) and power to the engine tach. Without emergency generator power to the FTIT (fan turbine inlet temperature) indicator, it is possible to get a hot start and burn up an engine without realizing it. If starting with an external aircart, there will be electrical power to both the tach and FTIT indicators at all times.

Under normal operation, the engine should light off approximately 10-15 seconds after pressurizing (throttle to idle). Initial fuel flow is usually 300-600 pph; higher flows proportionately increase the probability of hard light-offs and hot starts. Hot starts are a strong concern with this engine because of the potential damage to the engine under this low air flow situation. For that reason, FTIT should be watched carefully during starts. Even though 680°C is the limit, a reading of 450°C or more while RPM is still low (40% or less) indicates the start is going hot, and there is no reason to subject the engine to further punishment. In the event of a hot start, bringing the throttle to cut-off will immediately check the FTIT rise. In this situation, the engine will continue to windmill around 28% under JFS power, and a second start can be attemped after a 30 second delay for cooling.

Pre-flight engine checks should include a snap idle-to-mil accel and an A/B light. During the engine accel, monitoring the movement of the exhaust nozzle will show you if the engine is being scheduled normally by the UFC (unified fuel control). The characteristic nozzle response will soon be learned through experience. If the nozzle closes down to near zero and stays there, engine acceleration will be suppressed. Should it fly wide open at high RPM, the run-up should be discontinued immediately to preclude a fan overspeed. Oil pressure should also be checked carefully during the high power run; large fluctuations and pressure loss are indicative of oil underservice. The high power run also sets the engine trim level in the EEC (engine electronic control), thereby ensuring optimum performance for takeoff. At the end of the run a snap decel to idle is recommended, with a brief throttle reversal when RPM is below 75%. This is a rough check of the RCVV (rear compressor variable vane) scheduling and demonstrates that the compressor has sufficient stall margin for safe engine handling in the low RPM region.

Afterburner takeoffs are bound to impress even the coolest of high performance jocks, particularly with a clean airplane. Keep in mind that an inherent characteristic of a fan engine is a relatively large thrust loss with high ambient temperatures. Therefore, your most impressive takeoff will be that cold morning, max A/B effort. Conversely, the least impressive will be the high gross weight, high temperature, high elevation takeoff - particularly if a burner fails to light.

A brief suggestion on A/B takeoff technique: Hold the airplane with the brakes if possible (depending on gross weight, ambient temperature, etc.) while the engines are accelerated to mil power.

At brake release, pop both throttles into A/B (partial or max) and check the nozzle indicators to confirm a good light on both sides. If a burner fails (nozzle closes back to mil power position) at this early point in the roll, cycling the throttle to relight the burner is no problem. If you delay, however, you'll soon be dividing your attention between engine handling and rotating for takeoff. At a minimum, the throttle should be brought out of A/B after a blowout to shut off A/B fuel flow and prevent an auto-light with a closed nozzle.

Once airborne and climbing to altitude, you'll soon notice RPM and FTIT cutting back at mil power. This is normal while the UFC is on the N_2 (high compressor RPM) limit schedule, which is a function of T_{t_2} (inlet total temperature). During an accel to supersonic speeds, the engine will transition to the FTIT limit schedule in the low supersonic regions as T_{t_2} increases. While on the FTIT schedule, RPM and FTIT will be relatively constant and near their upper limits.

Engine stalls are easier to generate with a turbofan than with a straight turbojet because pressure spikes from the A/B have an unimpeded path right up the bypass duct to the back of the fan. Therefore, hard A/B lights can cause audible stalls. Usually these will consist of only a momentary self-clearing fan stall, but the accompanying bang will usually get your attention. As a matter of course, the engine parameters should be checked quickly, particularly FTIT, to make sure the stall hasn't driven the engine into stagnation (RPM dropping, FTIT rising).

Stagnations can only be cleared by shutting down and restarting the engine, which leads us into airstarts. Repressurization for an airstart should not be done before RPM reaches 50% or lower to insure the start bleed strap is open. Also, repressurizing should be done at no lower than 20% RPM so that light-off will take place before reaching an extremely low N_2. Temperature limit for airstarts is 800°C, based on warm thermocouples, less temperature lag, and plenty of airflow through the core. Ground starts are limited to a max FTIT of 680°C, since that represents an equivalent amount of heat to the engine with cool thermocouples and minimum airflow.

Here's hoping you enjoy the high performance the F100 engine provides. It's important to appreciate the fact that the core is being taxed heavily in terms of temperature and RPM to produce so much thrust from such a lightweight engine. Therefore, to ensure engine longevity and structural integrity, observe the limits carefully and log all overtemps.

DENNY BEHM/Experimental Test Pilot
(Eagle Driver No. 7)

Radar/Avionics

The radar in the Eagle is the backbone of a very unique system which gives the pilot a maximum amount of target information to assist in weapons delivery. Those of you with previous radar experience will find a scope that is very different from any you've seen. Those of you with no radar experience will be pleased to know that it is easy to become an expert operator in a very short time period.

To make the radar "one-man operable," we have tried to eliminate any difficulty in interpreting the displays. The operating characteristics that accomplish this goal are a good subject for a very lengthy book, but the pilot-related characteristics are pretty straightforward. First of all, the scope is "clean." The radar makes it possible to display a clutter-free environment which is the major improvement over previous systems. The pilot no longer needs to worry about discriminating between clutter and targets; the radar does it all.

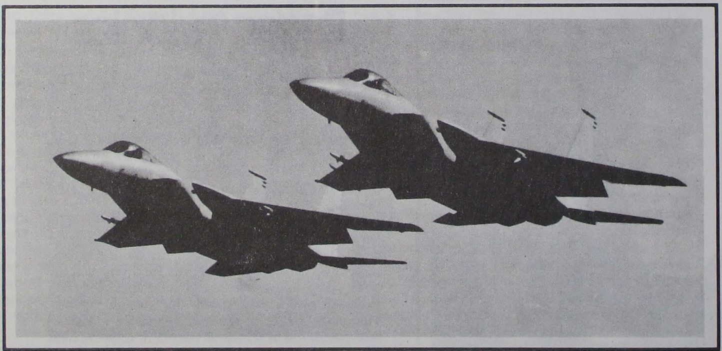
Another major pilot aid is the central computer. By tieing the radar to this computer, we have been able to automate many of the functions previously performed by the radar operator. You'll find automatic search and acquisition modes for various kinds of threats; the ability to match the radar display to the desired weapon by actuation of stick and throttle switches; and a complete integration of all the aircraft avionics to provide you with simultaneous weapons delivery, target identification, and navigation information. Another radar operator function we have deleted is the BIT check. The F-15 BIT system continuously monitors radar operation and alerts the pilot to failures. During normal operations, there is no need for pilot-initiated BIT's.

Historically, PD radars have been great in the head-on look-down environment but very weak in the tail-on or maneuvering situation. This radar, by the use of new technology, has greatly expanded our capability in those previously weak areas. The value of this capability will become obvious in the missile attack/reattack situations during which a dynamic maneuvering encounter develops. For the visual encounter, you'll find supersearch (the radar automatically acquires any target in the HUD field of view) an invaluable aid. The supersearch and boresight acquisition switch is on the stick so there is no need to refer to the radar control panel. Incidently, it also works very effectively for join-up after takeoff in weather or at night.

If your target is in a multiple plane formation, supersearch can be used to separate the targets in azimuth. When track is broken by reactivating supersearch with the switch on the stick, the system will lock on the next target with any azimuth separation from the original target. To complement supersearch, we have a boresight mode which can be used for range discrimination with multiple plane formations. When track is broken by reactivating the boresight mode, the radar acquires the next target in range along the boresight line. Thus the capability exists to define all elements in a formation with single switch actuation without removing your hands from the stick or throttles.

Once lock-on has been attained, the target flight environment will be completely defined for you. Target load factor, aspect angle, altitude, and speed will be displayed in digital format for easy interpretation. The ability to anticipate target maneuvers should be greatly enhanced with this information. Another pilot aid during the track phase is the target designator box. This square open-box symbol is located on the HUD and is space-positioned over the target during radar track. You'll find that early visual acquisition is much easier with this "TD" box.

In general, you'll find that we have been pretty successful in removing the requirement for radar operator technique. However, there are still some areas that will require a certain amount of interpretation and understanding to obtain maximum performance. For example, avionics cooling. We



have tried to provide a cooling system that will handle radar operation throughout the ground and flight envelopes but there will be times (failures, single engine operation at envelope extremes, etc.) where pilot judgment will mean the difference between a good "up" system and an overheated system. This system of black boxes is very sensitive to overheat, so treat it accordingly.

In the area of radar performance, there are several items that can cause problems if you're not alerted to them. Since the radar displays all targets synthetically, it must decide which targets are real and which are false before it displays them. In this process, several problems arise. A weak target may be painted only occasionally, and to the pilot this target may appear as a random false alarm. You'll have to learn through the use of frame storage and quick-look acquisitions, to discriminate between these weak targets and false alarms. In the training environment, especially in the area of high speed freeways, occasional ground moving targets (GMT's) will show up on the scope. Again, the pilot will have to learn to discriminate between these and normal airborne targets. In this case, your job is made easier by acquiring the target and checking his speed and altitude.

Another phenomenon that can cause concern is the possibility of "blind zones" at various combinations of target ground speeds and ranges. These blind zones are due to the basic physics involved in PD radars and fortunately they are very limited in this radar. So if you're painting a target on a consistent track and he suddenly either disappears or paints only occasionally, the odds are that he is in one of those blind zones. Wait a few seconds and pick him up as he comes out of the blind zone. Frame storage can again be helpful in keeping track of targets in these areas.

Another PD radar peculiarity that will become apparent during some join-ups or during some close-in tail chase situations is Jet Engine Modulation (JEM). The radar set has the capability of filtering most JEM out of the display but occasionally some will come through. It will appear as multiple targets at the same azimuth; so if you see a single target blossom into several targets as you close in range, you're probably looking at JEM. When you attempt acquisition, the radar will sort out the real target.

A final item to be aware of occurs at short range, especially when the target is a large aircraft. With a large target, the radar will hunt for a particular point of the airplane to acquire. For instance, during refueling join-ups on KC-135's it is not uncommon to see the radar jump from one engine to another. The VSD display will be a little jumpy and the HUD TD box actually jumps from one point of the airplane to another. Keep in mind that this will change your steering commands slightly during the final phase of the join-up. The target will be within visual range when this phenomenon occurs so it should not cause any real problem.

In conclusion, I think the best way to prepare yourself to use this weapons system is to spend the majority of your time learning the logic behind all the various modes. The ability to comprehend why the system reacts the way it does to various inputs from you or from other aircraft systems is very important in the operation of the radar. It is not necessary to understand the "black box" operation, but it is very important to understand all of the pilot-oriented mode logic. Once you have a good hold on this logic, the operation of the radar/weapons system will be a piece of cake!

STAN MCINTIRE/Experimental Test Pilot
(Eagle Driver No. 13)

Gun

After doing much of the test work with the M-61 gun in the F-15, my main impression is this: "You can't miss!"

That's a bold statement and assumes you properly employ all the avionics equipment associated with the total gun system. It is also an impression directed primarily at the air-to-air mode of the Eagle, but I really feel the same way about air-to-ground.

If you have gun or tracking experience in fighters, you are one up on the novice but the degree of success in your first Eagle dart pattern will probably not be much better than his. This is because the one-man operability of this gun system - utilizing the radar, HUD, HUD camera, or any other desired piece of equipment during firing - is optimized to the point that after one successful flight in this machine, you can hit with the gun.

In dealing with the air-to-air problem, there are only a couple of changes (other than the improved cockpit controls) in the F-15 from the F-4E that really have affected the ease of solution. First is the impressed or elevated gun line, which both in theory and practice makes tracking easier. Second, we have incorporated more parameters in the lead computing equation which gives a slightly increased probability of hits against all "time" types of targets; and we do display the necessary information on the HUD - in a slightly different fashion. There is much more information available on the HUD than we've ever had in fighters before; but my experience in the test program indicates that a pilot needs to fly a few gun flights before he can utilize effectively all that is displayed. Fortunately, this will not materially affect results on your first gun missions!

So let's take a look at how to kill the dart on your first pass in the Eagle. You've got all the necessary ground school, briefings, simulators, fam flights, and safety lectures out of the way, and heeding all that expert advice, have now arrived at the proper place to start your roll-in on the target.

I like to pick up the firing speed very quickly, trim the aircraft, and then handle the radar lock-on. Prior to rolling in, I set all controls that require any looking into the cockpit, including the Master Arm switch to ON and the Gun switch in the proper firing rate. If you remembered to turn on the HUD at takeoff, it's already working but I suggest for this maneuver that you put the Intensity switch in MANUAL and adjust brightness to the lowest level at which you can comfortably see the display. This prevents losing the sight at a critical point because of sun angle. The Reticle switch goes to AUTO and the Symbology switch can be in either NORMAL or REJECT if you don't like all the information displayed. The Camera switch on the trigger works good for this program. I'll assume the radar is on and working, so all you have left to do now is fly the aircraft and manipulate a few buttons on the stick and throttle.

Placing the Weapons switch on the right throttle to the rear (or Guns) position with your thumb puts the HUD in the proper mode to track regardless of prior selection. Now for the lock-on portion you can do this by pressing the Radar Reject button on the stick to the forward position for a boresight lock-on; aft if you want a supersearch lock. Boresight works best if you see the target clearly and it also gives the minimum time to lock up and get a computing solution. Beam width for the boresight is about 60 mils and range is out to ten miles, with reject and unlock capability at your right thumb.

You do have to fly the aircraft to place the proper target in the beam. When you get a lock-on, your first check should be to determine if you have the tow plane or the target and this is quite easy to do by seeing which one is inside the square radar box. If you locked the tow ship, it obviously doesn't mean you're in danger of shooting him down but the range info into the computer will have you overleading the target because you'll be shooting inside the displayed range. The best way to avoid this little inconvenience is not to hit boresight until you have the target only inside the beam width.

Supersearch comes in handy during those times when you've lost sight of the target during roll-in but still have the tow in sight. It takes a second or two longer to lock and then when the TD box comes up, you have about a fifty percent chance of getting the target position. If you have the tow, hit it again and you'll get the target with any luck at all. This also works well if you lose both tow and target during maneuvering but, of course, you need to use a little headwork when bearing in blind on something you don't see.

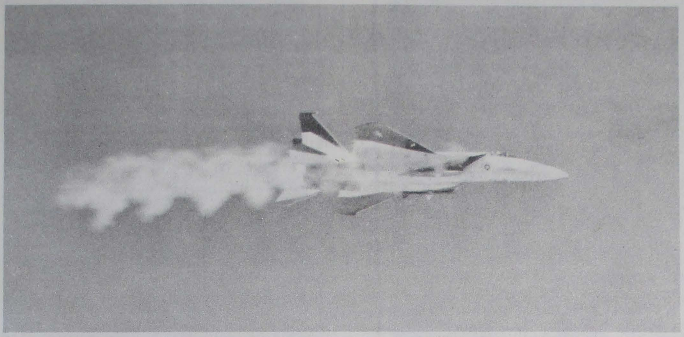
One tip on technique for either type of lock, but particularly the boresight - hold your altitude as long as possible and don't lock on until about four thousand feet in range or you'll get level to below the target at firing range. In my opinion, this does not cause a safety hazard with the tow plane but it does make tracking and speed control a little more of a problem. This situation occurs due to the geometry of tracking with an elevated gun.

Now you're locked up on the dart; you have it in sight; and you're displaying range on the gunsight. Check airspeed quickly and when the end of the range bar hits three thousand feet, get serious about tracking. Look at the target like you're going to burn a hole in it and fly the sight to the target. Don't stare at the sight - look through it to the target. This helps cut down the nervous jitter some pilots develop when doing a tight tracking task. At two thousand foot range (which is the two o'clock position as the range bar decreases counterclockwise), the pipper should be on the center of the target and steady for about one second.

Smoothly squeeze the trigger for a short burst and you should see pieces flying. If not, keep tracking and keep shooting. Break it off at the range the leader told you to, and let go of the trigger first. Roll wings level with the load factor still on and the airplane will climb clear of the dart, tow line, and tow ship without undue hazard.

Since I know you hit, I won't go through the next run but let me caution you to turn the Master Arm OFF while setting up. One reminder on gun trigger mechanization - if you have the Master Arm ON and the gun is loaded, it's going to fire anytime you pull the trigger regardless of throttle mode switch, HUD modes, or anything else. The trigger does one thing only armament-wise in this aircraft and that's fire the M-61, 20 mm cannon at the rate selected. It has two detents; the first is for running the HUD camera but the fully depressed position is "instant destruction."

The previously discussed mode is obviously the best to use if you expect a high degree of success in air-to-air situations, but there is also a back-up mode available in case the central computer (CC) dies. When that happens, the sight automatically reverts



to using the lead generated by the lead computing gyro. Radar range is still displayed and utilized if you are locked up. If the CC is good but the radar quits, the equation uses a fixed range of 2200 feet for generating lead. This obviously is also the radar rest range of the system. If you're in the secondary mode without radar, this range is 1,000 feet. One more control that is available at your finger tips is the electrical cage, or reticle stiffening if you prefer. Depressing this button, on the forward side of the left throttle, gives a 1,000 foot range into the computed lead also.

Using the gun in air-to-ground is really the same as in any other fighter with the exception of the effects of the elevated sight line. The mode requires a proper pipper depression for the intended firing range and airspeed. The HUD can be used in A/G mode, which allows you to depress the normal reticle or you can use the red standby reticle and depress it the desired number of mils. This allows you to use the ADI mode of the HUD, which brings the velocity vector of the HUD into view for use in drift correction. I personally like this mode the best because with the velocity vector, you can tell your precise dive angle and also get a feel for the true crosswind correction required.

The gun is boresighted to cross the sight line at 2250 feet range, so that is obviously a pretty good point in the dive to start shooting. In practice, you'll really want to start farther out because the Eagle with the elevated sight looks like you're going to park it in the sand about half-way between the foul line and the banner until you've watched this picture for a few flights. The visibility out the front and the viewing angle will be inherent aids toward preventing "over-pressing" those dives.

You can roll in on final with the pipper above the target, or the velocity vector very close to the bottom if drift is small, and slowly bring the pipper down as range decreases. Pitch response in the Eagle is quite sensitive so getting the trigger down smoothly helps the score in this mode. Pull-off should be smooth but quick, just like any other machine you've ever been in with one note of caution for possible CAS-OFF pull-outs. The CAS-OFF airplane is slightly less responsive and there is slightly less stabilator available, so don't press in so close. I surely advise some CAS-OFF practice to get a feel for this situation.

The elevated sight line eliminates most of the pendulum effects noted in previous systems when you're doing strafing, and consequently lateral corrections are a little easier. There will be a tendency to shoot at longer ranges but this should be overcome with a little experience. The Eagle was designed for the air-to-air role and it lets you do some fairly high g tracking at altitude without a trace of buffet. The same wing that does this also makes the ride a little rough in turbulent air in the air-to-ground pattern and this also takes some getting used to. However, with CAS on, the aircraft is highly damped in all axes so I don't think this is going to affect results as much as you might think on your first try.

With adequate preparation and the normal tendencies of fighter jocks to want to get with it, I know you'll have great shooting in the Eagle.

JACK KRINGS/Project Experimental Pilot
(Eagle Driver No. 8)

High AOA

Most of the other sections of this booklet describe aspects of the Eagle not likely to change, but at time of publication, we were still exploring F-15 high angle of attack characteristics. Check your latest issue of the PRODUCT SUPPORT DIGEST for most recent events, but as of November 1974, this is what it looked like -

One g stalls (CAS OFF) have been routinely done in four different airplanes and are repeatable. As angle of attack is increased, light to moderate buffet starts at about 21 units AOA. The buffet remains fairly constant as AOA is increased. At approximately 35 units AOA, mild (± 15° bank) wing rock occurs; and at full aft stick, 45+ units AOA (38° true), a slow dutch roll (± 15° bank, ± 5-10° sideslip) exists, and if sustained with continued full aft stick, will damp to essentially a stable full aft stick stall with no lateral/directional activity. The airspeed stabilizes at 90-100 knots. Full deflection lateral and/or directional control inputs cause a slow turn in the direction of control application. Full cross controls with full aft stick have been held for over one minute with no adverse airplane behavior.

CAS ON 1 g stalls are basically the same except that a higher AOA (40-42°) is reached at full aft stick. The dutch roll exhibited at the higher AOA is more divergent in yaw and is somewhat dependent on individual airplane CAS tuning.

Stalls (1 g) have been done at all engine power settings from IDLE to MAX AB with no adverse engine effects. Dynamic, wings-level, stalls have been made by abruptly pulling the stick to the aft stop at airspeeds from 140 knots to stall. The overshoot has produced AOA up to 65-70° and minimum speeds down to 0-15 knots. Maintaining full aft stick results in a slow nose-down pitch maneuver, stabilizing at the normal 1 g stall condition with slightly slower (70-80 knots) stabilized speed.

Accelerated stalls (CAS OFF) 2-4 g, produce a significant right roll between 25° and 35° AOA (35+ units AOA). Accelerated stalls from a right turn decelerate rapidly and stabilize at the same conditions as the 1 g stall. A left turn will roll over the top, decelerate, and stabilize at the 1 g stall condition.

Tests to date indicate the extended speedbrake has an adverse effect at high AOA (above 35 units). Stabilizing at 30° AOA (approximately 40 units) with CAS ON during accelerated stalls turning left produced significantly higher yaw rates with rolling departures. Recovery is positive with relaxed aft stick force, but there will be considerable further investigation of both the speedbrake and CAS contribution to this maneuver. Until further evaluation

of the extended speedbrake characteristics, they will be limited to 25° instead of the normal 43°. Incidently, CAS is presently designed to drop off at high yaw rates.

One inadvertent spin has been entered from the above condition. It was recovered using the predicted (and handbook) technique of full lateral control with the spin. Neither engine had flamed out, but they were stagnated. (As Pat Henry mentioned under "Propulsion," this necessitates a shutdown and restart.)

The 30 unit AOA operational limitation will give you a very maneuverable but docile flying machine with no "funnies" at all. As we get smarter, we fully expect to be able to open up this limit.

JOE DOBRONSKI/Director of Flight Operations
(Eagle Driver No. 18)

Superiority Across the Board

USAF specifications for the F-15 settled for nothing less than "superiority across the board" – in performance, propulsion, avionics, ordnance, etc., thus presenting the greatest challenge to the fighter aircraft industry in 15 years. You have just finished reading some first-hand accounts by several of our company test pilots, with their impressions on how well that challenge was met.

In accordance with specifications, we've designed that superiority into the airplane and demonstrated in our flight test program that it's really there. The next challenge is yours. We are confident you will feel at home in the Eagle in very short order, and once you learn the ease of operation of the extremely flexible weapons system, that you'll outperform, outshoot, and outlast anybody who opposes you. Guaranteed.

I guess by now it will be apparent to you that all of us at McDonnell are pretty proud of this airplane! Once you get your hands on it, we think you will be too. To see why, let's look at an important but representative area of performance – at "maneuverability."

To the combat pilot, the most vital and distinctive aspect of a fighter is maneuverability: "The capability (usually time-wise) of the aircraft to transition from a given condition of position and velocity (initial state) to a desired condition of position and velocity (final state)," or in other words – the ability to change altitude, speed, and turn rate in any combination and still maintain a high level of energy. How this capability was maximized in the Eagle is an interesting example of the combined effects of design theory and test practice.

To meet and, in many areas, exceed stringent demands on the F-15 design, over 23,000 hours of wind tunnel testing were performed before first flight. The wing required considerable design work to optimize it for low drag at both low and high lift; more than 100 wing/body combinations were tested prior to the time the proposal was submitted to the Air Force.

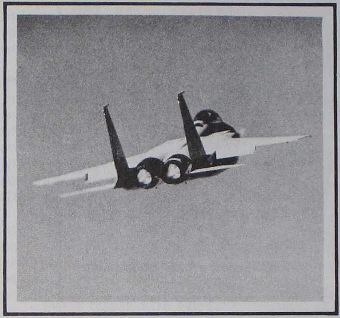
The wing is complex in shape to provide excellent maneuverability at high load factor, but it is relatively easy to assemble and maintain. It has no spoilers or leading edge flaps, and the only moving parts are a simple flap and a simple aileron. Redundant load paths have been designed into the wing, meaning the aircraft can sustain a fairly high level of battle damage, including missile and gunfire, without losing its basic maneuverability. (An interesting fallout of the F-15 wing design effort was the F-4 leading edge slat! A prototype slat, originally thought to be necessary to meet F-15 specs, was evaluated on an F-4 test bed to investigate the concept. Although simpler and more efficient ways evolved for the F-15, the Phantom became a better and safer fighter when it incorporated these same slats.)

It is curious a fact that fighter aircraft which have excellent maneuverability in the air combat arena inevitably duplicate this quality in the air-to-ground role. The reverse situation has never existed. However, most fighter pilots were apprehensive when the specs called for a fighter optimized for the air-to-air dogfight, but in muted tones required an air-to-ground strike capability. It is a tribute to McDonnell engineers that you have been provided with an outstanding strike capability in the Eagle without an ounce of compromise to its absolutely fantastic air superiority capabilities.

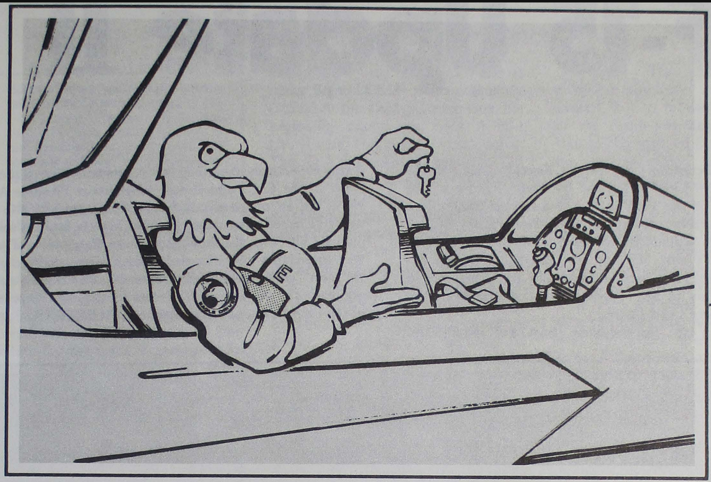
No significant changes were necessary to improve F-15 maneuvering characteristics to meet spec requirements. However, there was one modification to the wing tip shape, which consisted of removal of approximately 4½ square feet of wing area per side at the outboard aft wing tip, giving it a "raked" appearance. This change eliminated an objectionable buffet at 0.90 Mach and 30,000 feet, while also providing relief for outer wing loads. This "raked wing tip" configuration was also found to provide specific excess power (P_S) greater than the original wing tip during supersonic maximum power accelerations and maneuvering turns. No significant effects in P_S were seen during one g military power accelerations or during subsonic maneuvering turns.

Early flight tests also indicated the original speedbrake would not satisfy spec deceleration and descent performance requirements, and an annoying buffet was encountered at high speedbrake extension angles. A flight test program which involved twelve different speedbrake configurations was conducted before defining one that would satisfy both performance requirements and extension limits for acceptable buffet. This final production configuration has an area of 31.5 square feet versus the original 20. A compromise was reached between deceleration characteristics and acceptable buffet levels by limiting the brake extension angle (hinge moment limiting to 20 degrees) at speeds above 350 knots and allowing it to fully extend (43 degrees) during deceleration as dynamic pressure is reduced. Speedbrake operation during tracking tasks has little or no transients at extension or retraction, and there is minimal effect on the flying qualities of the aircraft at most conditions.

I believe you will be very pleased to find the Eagle displays an agility throughout the flight envelope which belies its size. The light and responsive control system, along with its low wing loading and high thrust-to-weight ratio, result in exciting characteristics for air combat maneuvering. Being able to accelerate to supersonic speeds while sustaining high g loads gives you the capability to gain an energy advantage over an opponent in very short order. The inherent stability of the F-15, coupled with the absence of engine stalls, wing rock, nose rise, and other undesirable high angle of attack characteristics, will encourage you to utilize the full maneuverability of the Eagle without inhibition!



And now that you've read all the good books, including this one, it's time to suit up and become Eagle Driver No____. You've got the keys to your new airplane, so be our guest . . .



[Sorry there are no keys left.
It didn't really work anyway.]

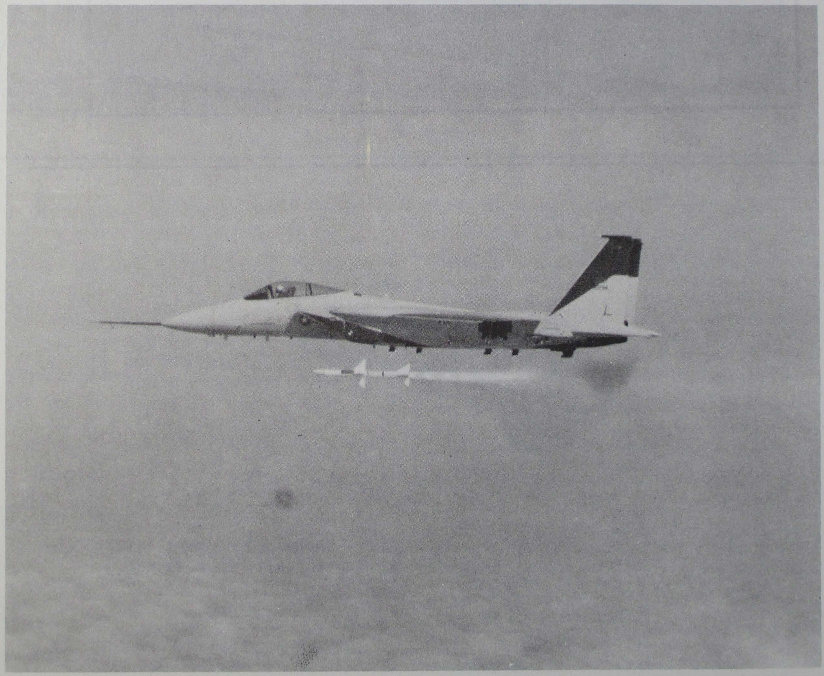
(1974)

F-15 Update II

In September of last year, USAF Colonel Wendell Shawler and McDonnell Chief Test Pilot Irv Burrows made a joint presentation on the F-15 to the 17th Annual Symposium of SETP (Society of Experimental Test Pilots) in Los Angeles. This September, for their 18th meeting, it was Pete Garrison's turn. Mr. Garrison, McDonnell's Chief Experimental Test Pilot, second man to fly the Eagle, and an Associate Fellow of SETP, brought his audience up to date on the Air Force's new fighter.

Pete gave a talk, showed some slides, and ran a movie which collectively described status and activities of the airplane in the Cat I and II test programs at Edwards AFB. We've got all of his words for you here, and it's too bad we can't include the movie because it gives, as Pete said in his talk, an "over the shoulder/you are there" view of some very interesting operational exercises. Since many of you are soon "going to be there" yourselves, we think you can get ready for the immediate future by reading this account of the recent past, as it was described for SETP/18 . . .

▶



F-15 Update II

By PETE GARRISON/*Chief Experimental Test Pilot*

Editor's Note: Pete's original presentation to SETP covered status of the F-15 program through early September 1974. This DIGEST version of his speech extends right up to first squadron delivery, just a few weeks ago.

Maintaining a low profile has been the by-word of the F-15 program from its inception, so it is not surprising that there is little more than general knowledge of the aircraft and its rather impressive accomplishments outside the small circle of individuals directly involved with the R & D program. This philosophy has merit in getting a program completed without the world looking over your shoulder and adding to your problems; however, it is not without its shortcomings when all goes well and you would like to spread the good word.

I am not in a position to argue the pros and cons of program exposure, but I can state that, combined with the traditional low key approach to public relations and advertising characteristic of McDonnell, this extremely successful aircraft evaluation program has come close to completion virtually unnoticed and unheralded. Whether it can be attributed to good luck, good management, or some of both, the Eagle is entering operational service on schedule, on cost, and as a completely operationally-capable aircraft.

I would like to bring you up to date on the F-15 test program and then compare the aircraft as it is being delivered to some of the challenging requirements which were originally set for it.

FLIGHT TEST PROGRAMS

The Eagle has been flying now for 30 months, and Category I testing has accumulated over 2700 hours and as many flights. USAF pilots have participated in the Cat I program from the beginning, completing eight AFPE's (Air Force Preliminary Evaluations). The Air Force formally started its Cat II program on schedule (14 March 1974) and has thus far added over 800 hours to the test totals. Six one-hour plus Category II evaluation flights in one day on the same aircraft, with the seventh flight being cancelled for lack of pilot crew rest (with the aircraft in OR status), unofficially tells us that the F-15 reliability, maintainability, and turnaround capability are working out as expected and then some.

Flight test demonstration milestones have been met per schedule, and the Eagle was turned over to the operational units with a zero loss and zero accident rate. Highlights of some of the individual programs show the aircraft at the finish line in achieving its original goals -

- Airframe major static testing and fatigue testing through four lifetimes has been completed for some time now. The flight loads program has been completed on schedule with no significant abnormalities showing up in any of the test conditions.

- Flutter testing has been accomplished in three configurations: clean, external fuel tanks, and the most critical conventional weapons loading, which happens to be two MK-82 bombs on each wing station. Flutter testing was completed before first production delivery with the exception of the Tactical Electronic Warfare System (TEWS). The TEWS pod configuration itself was not defined until late in the program, so a test article was not available.

- Aero/Stability/Handling - Testing of flight controls and handling is complete. Evaluation of low speed handling qualities, delayed because of failure of the flight test emergency power unit in Aircraft No. 8, was continued in conjunction with the spin program and completed prior to production delivery.

- Spin - The spin program has proved a problem - not due to the aircraft, but to the lack of reliability of the flight test Emergency Power Unit (EPU) required for installation in the spin test vehicle. After initial delayed qualification testing of the EPU system, the spin program commenced with normal investigation of the high angle of attack area. The results showed good handling, positive control, and definite spin resistance. Pre- and post-stall handling and control surface effects were evaluated up through pro spin controls being held with full aft stick for periods in excess of 30 seconds without spin entry. During a routine operational check, the EPU fuel system failed, resulting in a hold on the program and reappraisal of EPU reliability factors and subsequent decision to change the flight test emergency power system to a battery type.

During this lay-up of No. 8, F-15 No. 1 inadvertently advanced the cause of the spin program a considerable degree during high angle of attack investigation of the modified speed brake. The testing being performed was a wind-up turn at 40,000 feet to 80% limit load factor with speed brake fully extended. At approximately 30 units angle of attack, the aircraft rolled right two turns and then stabilized. Spin recovery was accomplished with normal spin recovery controls at between 25,000 and 30,000 feet. Methods of limiting speed brake extension angles at the higher angles of attack are being developed as part of the spin program. It goes without saying that recovery of the aircraft from the inadvertent spin with normal control action was most gratifying. When the spin program resumed, this configuration and its contribution to decreasing the basic spin resistance of the production configuration was further investigated. We have apparently found a way to generate a spin mode in the aircraft, and recovery looks normal and positive. Aircraft No. 8 is flying again and confirming good low speed handling qualities and strong resistance to spin entry.

- Missiles - 59 AIM-7F missiles

have been launched or jettisoned in testing. Bench testing, captive testing, jettison testing, and separation work are all complete. Sparrow tactical firings against drone targets have been completely successful. Captive carriage reliability of the missile is computed at better than 475 mean flight hours between failures, and we expect this number to exceed 500 by the time testing is completed and all the data counted.

AIM-9E qualification testing is already completed, with all launch and jettison conditions satisfied. Sidewinder tactical firings against drone targets have been equally successful to those with the Sparrow. AIM-9L testing will be resumed upon availability of test hardware.

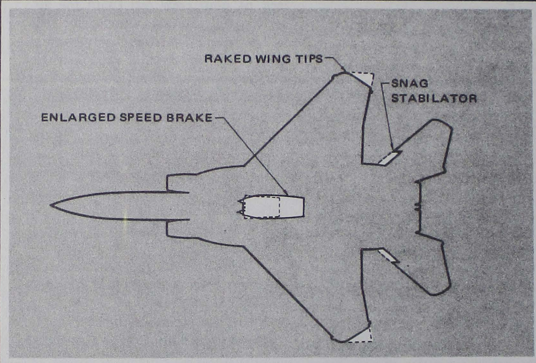
- Gun - The M61 gun has been qualified in the aircraft, and testing is complete. Firing was accomplished throughout the envelope with no gun, aircraft, inlet, or engine problems.
- Stores - All carriage equipment has been qualified and almost 100 multicarriage bomb loads have been jettisoned or separated up to 1.4 Mach Number. Air-to-ground weapons flutter testing is complete. External fuel tanks and pylons have been qualified, and 52 jettison tests were accomplished to complete the program.
- Engine - The F100 engine has always shown itself as an extremely tough, powerful, and basically reliable engine. However, as was expected of a new development program designed to qualify an engine for the extremes of air-to-air combat, early testing produced its share of discrepancies. Early engine problem areas involved stalls and stagnation, A/B light envelope and operation, airstart envelope, and engine response and handling. Each subsequent test engine model improved one or more of these characteristics, and the production F100(3) engine is now demonstrating satisfactory performance in all areas deficient in earlier test engines.
- Reliability, maintainability, and supportability are better than guaranteed. Demonstrated capabilities in specific areas covered by contract have all been well within the challenging requirements originally established. Two recent examples are the engine change demonstration in 18 minutes 55 seconds to satisfy a 30-minute requirement; and combat turnaround (loading missiles, ammo, LOX, fuel, oil service, and cursory inspection) in 5 minutes 50 seconds from the time the pilot opens the canopy after shutdown until engine start for the next mission. The requirement in this case was 12 minutes.

DESIGN STABILITY

Because of early design verification and heavy emphasis on early and extensive ground testing and proof testing, a high degree of design stability was achieved in the F-15. There has been little change required in the aircraft since the production configuration was finalized. A total of only 36 Class I ECP's (engineering change proposals) have been approved for incorporation into the program, of which only 23 apply to the aircraft itself. Of these, 21 are incorporated in the first production delivery aircraft, and all 23 will be incorporated from No. 3 up. (The two changes that miss the first production aircraft, incidentally, are minor in nature, one being a reroute of a wire bundle and another being the change of a bolt in a linkage assembly.)

This is not to say that this is the grand total of all changes on the program. There is another engineering document, called the VECP or Value Engineering Change Proposal, covering changes equally important to the program. The VECP happily saves rather than costs program dollars, being submitted to cover such things as reduced scope of testing, change to a test procedure to achieve increased efficiency, or reduced requirements for equipment or test time. Over 100 VECP's have been approved and incorporated into the F-15 program; the contractor ground test program alone accounted for 30 VECP's which resulted in over 20 million dollars reduction in program testing and procurement expenses. Similar savings can be attributed to VECP's arising from the flight test program.

Weight growth of the Eagle since first flight is only 460 pounds. Of this, less than 100 pounds are accountable to the airframe, the balance being engine-related. Weight growth of an aircraft as it progresses through its development program can basically be tied to modifications necessary to correct defects. Therefore, the abnormally low aircraft weight increase of the F-15 in achieving full production status speaks highly of both its capability and design stability.



The visible changes which will be seen in the production aircraft compared to the No. 1 test vehicle are few in number. Some of the more significant are:

- Raked Wing Tips - The flight program revealed a slightly different load distribution than had been predicted from wind tunnel work. The loading produced a higher outer wing bending moment, which reduced the required 50% margin. The minor wing tip modification solved the basic problem by redistributing the loading as desired and also produced some highly beneficial fall-out by reducing high angle of attack-high 'g' buffet, improving transonic performance, and also providing a slight weight reduction. ▶

• Snag Stabilator - Early wind tunnel testing revealed an empennage flutter problem which required a change in mass distribution of the stabilator and a minor shift of Cp aft and outboard. Both were satisfied with the snag configuration which was developed in the tunnel. Due to a concurrent manufacturing and testing schedule, the first three test aircraft were completed with the straight leading edge stabilator and were flown in a restricted envelope until the production stabilator was retrofitted early in the flight test program.

• Speed brake - The enlarged and retailored speed brake was the result of an initial configuration which produced undesirable buffet at the required levels of drag. The increased area and revised shape of the new speed brake produced the required drag at lower extension angles and decreased the flow interference on the vertical stabilizers. The speed brake is presently undergoing evaluation at high angles of attack.

• Crosswind Landing - Although not outwardly apparent, the production F-15 has a revised main landing gear strut and a revision in the flight control augmentation system after touchdown as compared to the original configuration on the No. 1 test article. Irv Burrows covered the crosswind landing problem and cures last year, so I will just confirm that all production aircraft have a full crosswind landing capability.

• Air-to-Ground Capability - Although air-to-ground capability does not represent a change, it may come as a surprise to some when they see an aircraft designed for air superiority loaded for an attack role. In truth, air-to-ground has always been considered for the F-15, but always with the overriding requirement that it could in no way impair the air superiority role. The Eagle has adapted to this secondary "fall-out" role with no problem. In brief, the aircraft has excellent air-to-ground carriage capability while still retaining its air-to-air armament, and can deliver stores in computed modes with an accuracy equivalent to that of dedicated air-to-ground aircraft. The trouble-free operation of the unique F-15 aft pivot/restrained jettison system throughout the explored envelope is additional testimonial to the design stability.

GROWTH

A configuration which we are presently flying and feel will provide considerable growth potential for the aircraft is called "Fast Pack" - Fuel and Sensor Tactical Package. The Fast Pack, or fuel pallet as it was originally called, is a pair of streamlined area-ruled one-piece external tanks nested along each side of the fuselage in the wing root area. The configuration now flying is a wet fuel cell, which adds approximately 10,000 pounds of fuel to the F-15's 11,000 pound internal capacity. The three standard 600-gallon external tanks can be carried in addition to the pallet tanks.

On 26 August 1974, a TF-15 in this configuration, with Air Force Colonel Wendell Shawler and McDonnell's Irv Burrows aboard, made a non-refueled Transatlantic crossing from Loring Air Force Base, Maine, to Bentwaters, England, in approximately five hours. That aircraft subsequently flew 92 demonstration flights in 43 days from several bases with an operational availability of 100% and an overall MMH/FH figure of 4.25 for the entire tour! (Incidentally, there's some data straight from the airplane's cockpit on this very interesting month and a half, elsewhere in this magazine.)

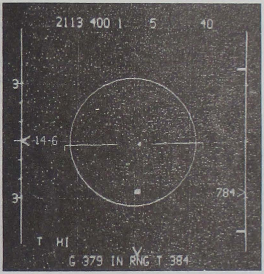
The Fast Pack provides sufficient extra room that fuel capacity can be shared with any number and variety of other operational capabilities in various options. The unit is designed for easy installation/removal in 10-15 minutes using existing AGE. Its installation does not affect the number of weapons stations and does not detract from the prime air superiority role of the aircraft. The pallet tanks have been flown to Mach 2.0 with no problems noted. Buffet and handling qualities appear similar to the clean configuration.

All present weapons, tanks, and stores can be carried in conjunction with the pallets in equal or greater numbers. Flight data to date is supporting wind tunnel indications of subsonic drag being no greater than the basic aircraft and a supersonic incremental drag of about one-third that of the equivalent amount of fuel carried in normal external tanks. The global deployment and multi-mission potential plus the ability to utilize the aircraft in a variety of missions through a dedicated pallet while always retaining air superiority capability indicate an encouraging future for the Fast Pack concept.

In closing, let's take a quick look at one of the main reasons for the success of the "one-man operability" concept of the F-15 - the VSD, or Vertical Situation Display. The F-15 radar offers a "clean" scope, presenting only target information. This photograph of the radar scope in the Long Range Search (LRS) Track Mode shows both the clarity of the computed display and the various readouts available to the pilot.

VSD READOUTS (FROM TOP LEFT)

4-digit time code
target speed
target 'g'
aspect from target
selected range scale
Rmax and Rmin
closing velocity/target range
TAS
in range/time of flight
antenna lateral displacement caret
ground speed
PRF information
target altitude
antenna elevation caret
scale numbers
allowable steering error circle (ASE), steering dot, target and horizon



As a test pilot, and speaking to test pilots, I am aware that traditionally, flight test must play the role of a hard-nosed analyst evaluating the product in a calculated and detached manner. While we at McDonnell have followed tradition religiously, this aircraft, its capabilities, and the way it is measuring up make it easy for any pilot flying or evaluating it to become an enthusiastic advocate. With the Cat I Program essentially completed and the Eagle now being delivered, the tactical units will be discovering for themselves that it's all true . . . and it's all good! ■

(1974)

FAST PACK TO

Engineering Program

By JOHN WARAKOMSKI/ *Chief Project Technical Engineer, F-15*

All of the factors that make the F-15 an outstanding air superiority fighter, such as low wing loading, high thrust-to-weight ratio, rugged structural design, flexible digital avionics, high reliability, and ease of maintenance, also provide the airplane with exceptional versatility and growth potential. So it was that, shortly after award of the F-15 contract and well before first flight, in-house Advanced Engineering studies were begun to fully assess this versatility and potential and to find ways of exploiting both.

One major result of these studies was the "FAST PACK" concept (Fuel And Sensor Tactical Package). Fast Packs are high-volume, low-drag conformal shapes that fit against the fuselage just under the wing, and which can be used to carry fuel and/or equipment (Figure 1). Fast Packs permit the F-15 to maintain the same number of weapon carrying stations for air-to-air and air-to-ground missions, while providing extended range and mission capabilities. They do not produce any increase in subsonic drag, and excellent performance is also retained at supersonic speeds where the drag of the Fast Packs is less than one-third that of the three external fuel tanks (Figure 2, page 30).

To evaluate and demonstrate the Fast Pack concept, the fuel pallet configuration with Sparrow missiles was selected for a McDonnell Douglas initiated and funded prototype program. This program was started in March and completed in August of this year. To meet this compressed schedule, everything was kept as simple as possible, including our methods of construction in a prototype shop. We had approximately 175 engineers, technicians, and shop specialists on the program, working on a three-shift per day schedule. Here is what we came up with –

The fuel pallets are area-ruled, conformal fuel tanks with a total capacity of 10,000 pounds of JP-4 fuel (which almost doubles the internal fuel capacity of the airplane). Pallets are non-jettisonable, but are designed for quick installation and removal. They are of conventional, semi-monocoque construction (32.5 feet long with maximum cross-section 24 x 36 inches) consisting of bulkheads, frames, stringers, longerons, and riveted skin. They are "wet" tanks with no internal bladders or liners, being internally sealed with a polysulfide sealer during assembly. Aluminum is the primary construction material, with steel utilized only in highly loaded areas and for pallet attach fittings. All major pallet structure and support fittings are aligned with existing airplane hardpoints in order to minimize airplane modifications.

Structurally, the pallets are designed for the full load factor capability of the airplane. A flexible finger-type seal is attached to the periphery of the pallets for aerodynamic sealing with the airplane. Each pallet is divided into three separate compartments for CG control and to minimize fuel slosh loads. The fuel system provides automatic CG control without pilot monitoring. Primary fuel transfer is by two

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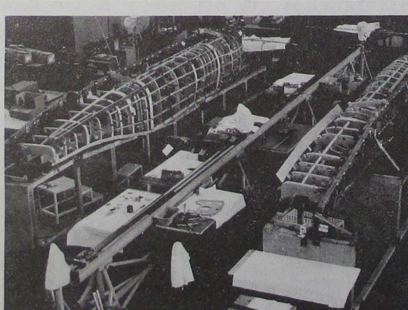
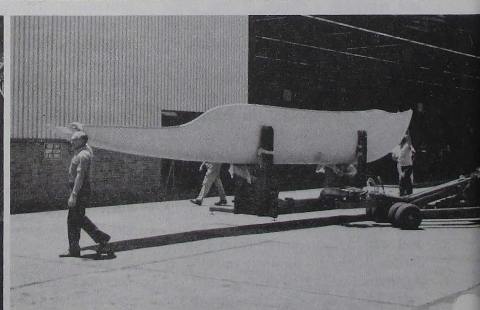


Prototype Fuel Pallets Under Construction



Pallet Configuration

FARNBOROUGH
Operational Evaluation

By Irv BURROWS/ *Chief Test Pilot*

The vital statistics of the F-15 demonstration trip to England and Germany are eye poppers and strong testimony to the operational deployment capabilities of the Eagle. I'll lay these numbers on you shortly, but for openers, let's talk a little about the overall philosophy behind the trip.

Our company was (and is) extremely interested in developing the "FAST PACK" concept – the large pallet tanks nested against the fuselage under the wings. These tanks, if used only for supplemental fuel, boost the "internal" fuel capacity by some 10,000 pounds. I say internal because these pallet tanks don't really strike me as externals in the sense of those big sausages that normally must be hung under the wings to boost fuel capacity. Fast Packs are nonjettisonable (although the fuel can be dumped) and handling-wise have no impact on the basic aircraft. Drag is not degraded subsonically; and though supersonic performance is somewhat lower, it's still a Mach 2 plus aircraft. So, to me, it's a fighter airplane in every respect, with two fighters' worth of fuel in it!

Given the chance by the Air Force to develop these tanks, we wanted to use them to help our airplane make the long trip to England late last August for public display at the Farnborough International Air Show. The plan that evolved, then, amounted to a joint effort – USAF/MDC – to demonstrate the F-15 deployment capabilities with pallets, show off a bit at Farnborough, and then introduce the Eagle to some very important folks – USAFE at Ramstein. We feel that everybody who had a hand in the expedition, and everybody who watched, is very happy at the outcome.

There was a brief pallet tank evaluation program at St. Louis and EAFB, as described across the page by John Warakomski. That program ended on the 22nd of August, and four days later, Colonel Wendy Shawler, Vice Commander of the 4950th Test Wing (and first Air Force pilot to fly the F-15) strapped on the heavy TF-15 (67,000 pounds with approximately 32,300 pounds of fuel in the pallets, externals, and normal internal) at Loring AFB, Maine. I rode shotgun and thus was an onboard witness of the takeoff roll of about 3500 feet – not bad for that weight! A little over five hours later we touched down at Bentwaters after a typical radar-vectored descent to GCA, and one low go. Had we continued to overhead, we'd have arrived there with 3800 pounds in 4 + 59 – nonrefueled. Pretty nice legs for an Eagle!

Our demonstration work began almost instantly (next morning to be exact), with USAFE boss, General John W. Vogt Jr. flying out of Bentwaters with Colonel Shawler in the front chair. On to Farnborough that afternoon and the next 13 days were spent practicing for and participating in the big air show of the year. The weather was unfriendly; and on about half of our appearances, we were forced to flatten out the vertical maneuvers in order to stay under the overcast or black rain clouds. I think, however, the airplane impressed

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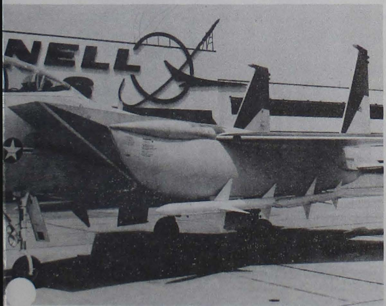
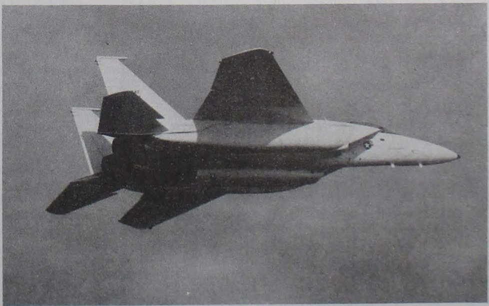
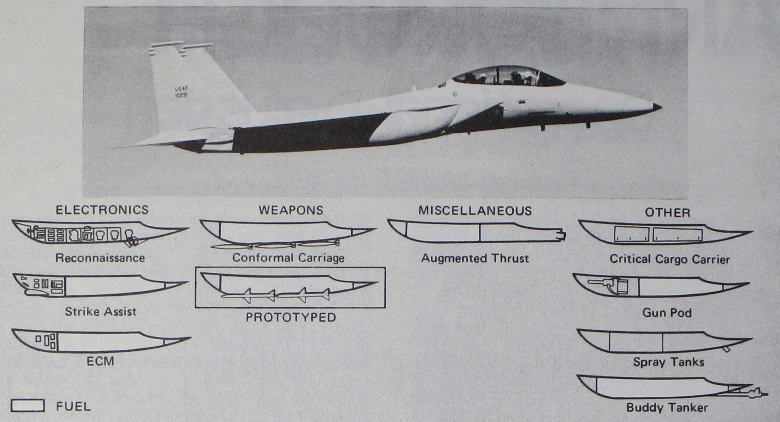


Pallet Installation



Fast Pack in Flight

FIGURE 1 - FAST PACK EXPANDS MISSION CAPABILITIES

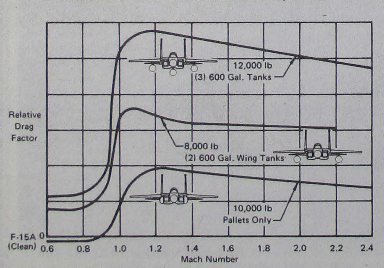


electric fuel pumps in each pallet, with one hydraulic fuel pump in each pallet providing back-up fuel transfer capability.

The pallets are filled through the existing airplane ground and inflight refuel receptacles. Inflight fuel dump is through the existing airplane dump system. A defuel receptacle is provided in each pallet to allow ground defueling without the use of electrical power. Each pallet has its own fuel gaging system providing a continuous fuel level reading, as well as its own individual ram air pressurization and venting system. Only existing, proven, off-the-shelf fuel, hydraulic, gaging, and electrical components are used. Sealed access doors are provided on the upper surface of the pallets for pallet maintenance.

The pallets are attached to the airplane by three self-aligning slip fittings along the upper inboard edge and two bolts along the lower inboard edge. The pallet/airplane system interface is equally simple, consisting of two hydraulic quick disconnects, one electrical connector, and a single fuel interconnect. The fuel connection is a probe on the pallet and a spring-loaded poppet valve socket fitting on the airplane, providing an automatic fuel connection as the pallet is installed. Attachment of a pallet consists of lifting it into place with a standard USAF bomb lift truck and two cradle adapters, installing two bolts, and making three quick system connections. The pallets can be installed or removed in less than 10 minutes. Normal airplane servicing and maintenance, including engine change, can be performed with pallets installed.

FIGURE 2 - LOW DRAG FUEL CARRIAGE



After completion of the prototype pallets and a short ground test program to assure structural integrity and proper system operation, the first flight of the pallet airplane was made on 27 July 1974, just 139 days after program go-ahead. The flight test program was successfully concluded on 22 August 1974. Twenty-one flights were made with various airplane configurations, including clean pallets, pallets with Sparrow missiles, and pallets with external fuel tanks, for a total of 37.1 hours.

During this short flight test program, a number of significant milestones were achieved. A load factor of over five g's was demonstrated and a speed of over Mach 2.0 was flown. A high gross weight takeoff at approximately 66,000 pounds was made along with an un-refueled flight duration of well over five hours. The cruise performance of the airplane with pallets was equal to, or better than, the basic airplane and the cruise drag was less than the clean airplane. Flying qualities at all speeds in both the clean and landing configuration remained unchanged from the basic airplane. There were no subsystem or functional problems with the pallet or pallet-related airplane systems. The flight test program was an unqualified success and convincingly verified our Fast Pack concept. For what happened next, turn back now to Mr. Burrow's presentation!

hundreds of thousands of onlookers on each of the eight show days. Demo rides were given late each afternoon after the regular show was over; and the back seat of the Eagle took on a distinctly international flavor as military representatives of several nations flew with us.

On the 9th of September, Colonel Shawler flew to Ramstein, having taken off with full pallet fuel but no externals. After a 1.6 hour flight, he landed, greeted the local wine queen, and turned the airplane over to Colonel Frank Bloomcamp, Commander of the 4486th Test Squadron (and another veteran of the Edwards JTF program). He took the USAFE Vice Chief, Lt General Bryce Poe, for a demonstration flight lasting 1.1. The airplane was not touched between flights; and the assembled crowd was amazed that this could be done without the normal herd of fuel trucks and AGE assembling beneath the bird.

Thus started an intensive get-acquainted session with USAFE. For the next nine working days, TF-2 flew at least three times per, and on two days four times. More flights could have been made – this schedule was quite easy to handle. The maintenance guys from our gracious host squadron, the 526th, watched with interest as the McDonnell crew performed the routine pre- and post-flights and the very few minor maintenance items. Their chins dropped too, as our guys swapped an engine between the second and third flights on the 20th of September.

On the 22nd, Wendy Shawler showed the Eagle's stuff in the huge Ramstein open house air show. The next day, he and Major "Mac" MacFarlane (one of the earliest Eagle Drivers from the Cat I program) made the long (9.6 hours) return trip to the U.S., landing at Andrews AFB after cruising with the tankers most of the way home. Andrews was the scene, for the next couple weeks, of some 34 demo flights for USAF, USN, and government people; Colonels Shawler and Bloomcamp were kept busy climbing in and out! Four flights per day were flown on five occasions; and five flights were made on the Eagle's last day at Andrews.

The odyssey of the Eagle ended on October 5th, when Colonel Bloomcamp and Major John Eckert brought TF-2 back to St. Louis – 92 flights and 100 plus flight hours after its departure from Loring a few weeks earlier. These numbers work out to an average of 71 flight hours/month, and it took our maintenance people just 4.25 MMH to keep us in the air for each one of those 100 FH! We experienced two flight delays for maintenance and three for fog, but did not have to cancel or miss a single planned flight in the entire 37 days of scheduled flying operations.

We think the F-15 again showed its mettle during this interesting and busy program. The "Fast Pack" fuel configuration was certainly verified as a viable deployment concept; and numerous other positive facets of the Eagle's character were identified. TF-2 flew and flew and flew, required very little care and feeding, and did great things while airborne. And to top it all off, it was a heck of a lot of fun, because as I've said before, the Eagle is "fun to fly," and we sure flew a lot between August 25th and October 5th!

Incidentally, TF-2, after its month and a half of glory, went right back to work as one of the Cat II airplanes at Edwards AFB. There are no prima donnas among Eagles. ■

SETP Award for 1974 to IRV BURROWS

Captain Iven C. Kincheloe was a jet ace of the Korean War, set a world's altitude record in 1956 in a Bell X-2 rocketplane, and was an extremely active and productive Air Force test pilot. He lost his life in 1958 in the crash of a test aircraft at Edwards Air Force Base, California.

Since 1958, the Society of Experimental Test Pilots (SETP) has recognized each year the test pilot whom its members consider to best represent the qualities and achievements of Captain Kincheloe. Among past recipients of the *"Kincheloe Award for outstanding professional accomplishment in the conduct of flight testing"* have been the Mercury and Apollo astronaut teams; and pilots on the XV-3, X-15, XB-70, F-111, and several commercial aircraft programs.

Winner last year was Chuck Sewell of Grumman for his work in F-14 spin prevention testing; winner in 1962 was then McDonnell pilot Don McCracken for his F-4 high mach and pre-compressor cooling investigations. Irv Burrows, McDonnell Chief Test Pilot, is the latest recipient of the Kincheloe Award, for his outstanding accomplishments in the F-15 flight test program over the past two years.

Pilot on the first flight of the Eagle on 27 July 1972, and with more than 250 hours in the airplane since, Irv insists on sharing this SETP recognition with his fellow McDonnell test pilots. We endorse both the society's selection of Mr. Burrows and Irv's acknowledgement of the pilots listed on page13, for another mark of the good test pilot is the way in which he shares the things learned in a test program. Since beginning in 1960 on the F-4 and continuing into the F-15 today, Irv and the other company test pilots have supplied the PRODUCT SUPPORT DIGEST and its military readership with more than 100 articles recording their flight testing experiences and opinions. No small part of the success of both the Phantom and Eagle programs is due to this corporate-wide emphasis on learning and then sharing.

product support digest

digest

F-15 72-119 "ready to go" on assault of Time-to-Climb records. Back cover photo by TSgt Ken DeWitt, 67 RTS of Bergstrom AFB "reflects" a 12 TRS RF-4C during a recent European deployment.

JOHN F. SUTHERLAND / Vice President, Product Support; THOMAS L. PLEIN/Director, Product Service; VERNON E. TEIG/ Director, Support Operations.

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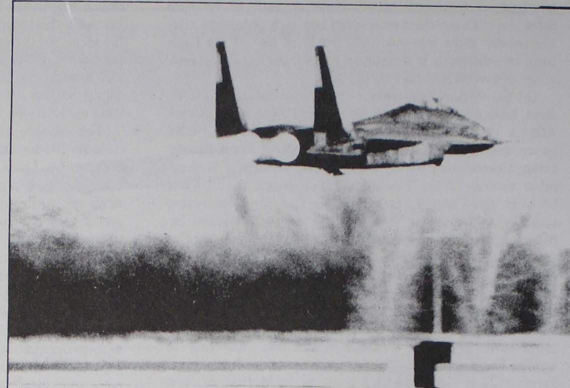
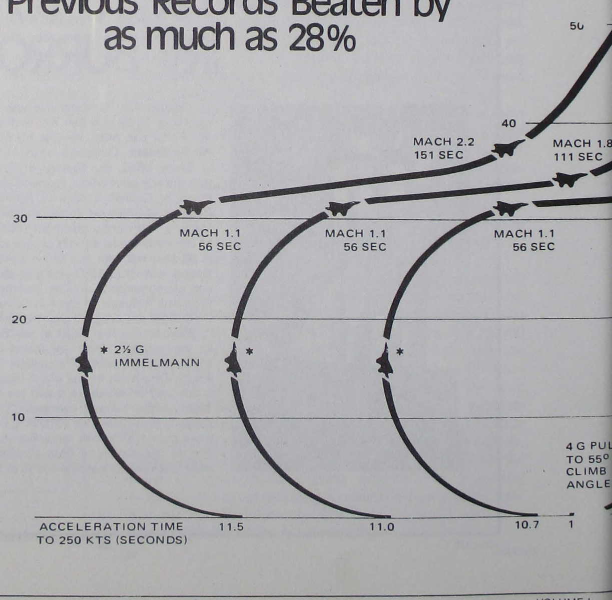


F-15 SMASHES FOXBAT CLIMB MARKS!

Previous Records Beaten by as much as 28%



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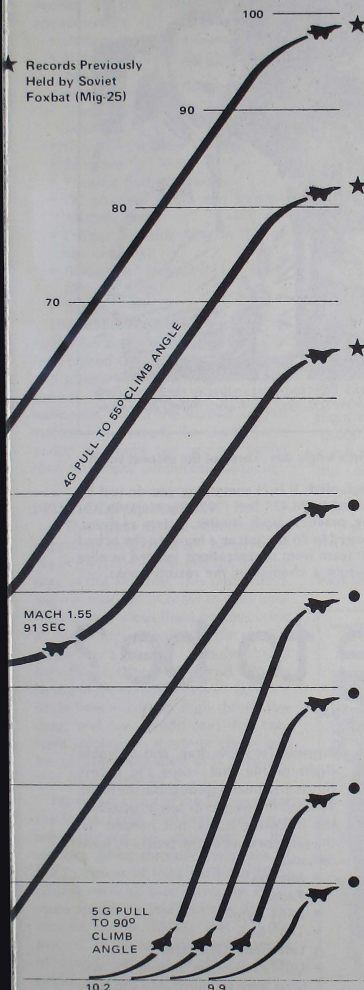
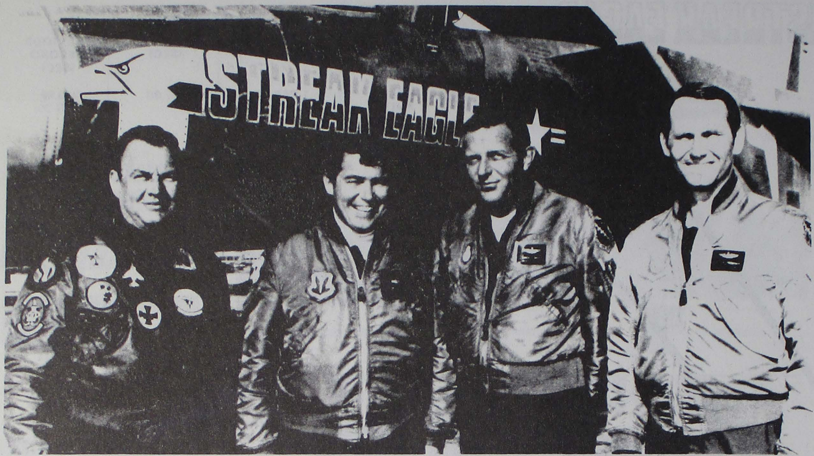
STREAK EAGLE



	ALTITUDE (FT)	PILOT	DATE	TIME (SEC)	PREVIOUS RECORD (SEC)
★	98,425 (30,000 M)	MAJ R. SMITH	1 FEB 75	207.80	243.86 (MIG-25)
★	82,021 (25,000 M)	MAJ D.W. PETERSON	26 JAN 75	161.02	192.60 (MIG-25)
★	65,617 (20,000 M)	MAJ R. SMITH	19 JAN 75	122.94	169.80 (MIG-25)
●	49,212 (15,000 M)	MAJ D.W. PETERSON	16 JAN 75	77.04	114.50 (F-4)
●	39,370 (12,000 M)	MAJ W.R. MACFARLANE	16 JAN 75	59.38	77.14 (F-4)
●	29,528 (9,000 M)	MAJ W.R. MACFARLANE	16 JAN 75	48.86	61.68 (F-4)
●	19,685 (6,000 M)	MAJ W.R. MACFARLANE	16 JAN 75	39.33	48.79 (F-4)
●	9,843 (3,000 M)	MAJ R. SMITH	16 JAN 75	27.57	34.52 (F-4)



McDonnell Chief Experimental Test Pilot Pete Garrison (left), who did much of the preliminary flight test work leading to the Streak Eagle record flights, is shown with the Air Force Pilots who set those records. Continuing from the left, they are Majors Willard Macfarlane, Roger Smith, and David Peterson.

Eight world-class time-to-climb records in just six flights. Five of the records set in a single day. Three of the records set in a single flight. Previous records beaten by as much as 28 percent.

The above statistics make Project Streak Eagle look pretty simple but don't be fooled; it isn't something you do just by putting a pilot into an airplane and saying "Go!" When Major Roger Smith streaked to 98,425 feet (30,000 meters) in just 207.8 seconds from brake release, he brought to fulfillment over a year's planning, practice, trade studies, system analyses, airplane modifications, and the task of bringing together all the organizations required to do the job as a team. In the actual flight program, Grand Forks Air Force Base, North Dakota, hosted a Streak Eagle team from organizations located in nine states. The following articles tell the story of the project, and how the F-15 wrote a chapter in the record books.

How did it come to be?

By RICHARD S. CAHILL/*Project Development Engineer*

The initial consideration of challenging the time-to-climb records with the F-15 came in the Fall of 1973, early in the developmental stage of the Eagle. With the limited amount of flight performance data available at the time, it was obvious that the F-15 could easily break records presently held by our own Phantom. It was not so obvious that it could also regain the records claimed by the Russian MIG-25 Foxbat. With this in mind, Air Force and McDonnell management wisely decided to wait until the airplane was further along in its development, and more of a known quantity, before embarking on a program that would place the airplane in an environment it had never experienced before. During this period, trade studies, performance analyses, and overall program planning took place.

INGREDIENTS

What does it take to set time-to-climb records? First, it takes a mighty good airplane just to try it (look at the previous record holders — the Phantom and the Foxbat). Then it takes a thrust-to-weight ratio higher than anyone else's, low drag, and a flyable flight profile that keeps the excess thrust maximized throughout the flight. To keep the weight as low as possible, the following items, not needed for the safe conduct of the program, were removed:

- Missiles
- Radar
- M-61 Cannon
- Tail Hook
- Left Hand Generator
- Utility Hydraulic System (PC systems were plumbed into the Utility system

- Flap and Speedbrake Actuators
- Paint

On the other side of that coin was the addition of special equipment needed for the environment to be encountered:

- Battery Packs and Controls
- Holdback Device (in place of tail hook)
- Noseboom with "Alpha" and "Beta" Vanes (angle of attack and sideslip)
- Over-the-Shoulder Camera
- Sensitive "g" Meter
- Pressure Suit Provisions
- DC powered Radio and Standby Attitude Gyro
- C-Band Tracking Beacon (for radar tracking)
- Barograph (required by international rules)
- Ballast

The additional equipment was required because the higher record profiles placed the airplane at altitudes and speeds where the engines would have to be shut down, thereby eliminating the use of the normal aircraft systems. As a result, the Streak Eagle ended up about ten percent lighter than an empty production airplane.

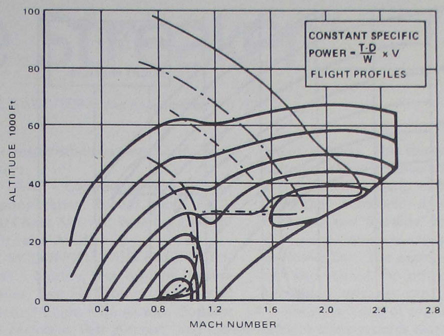
PROFILE DEVELOPMENT

The exact profile development depended on a thorough understanding of the thrust of the engines and the drag of the airplane. This understanding was required in order to start optimizing the various flight profiles using a parameter called *specific excess power*, or Ps for short. Ps is developed from thrust, drag, weight, and velocity by use of the equation $Ps = T-D/W \times V$ (note how important high thrust, low drag, and low weight are). For constant velocity, Ps is rate of climb, and for constant altitudes, it is acceleration (multiplied by V/G).

Figure 1 is a plot of the Ps curves for the Streak Eagle. The best climb rates are achieved by climbing at the velocity going through the peaks of the Ps curves at least until the flight path is vertical, then strive for maximum speed. As you can see, for the records up to 50,000 feet (15,000 meters), climbing at or near the speed of sound keeps you right on those peaks.

In the Streak Eagle program the flight profiles were determined through computer analysis of various climb angles and rotation techniques. For the 3,000 meter flight, and for the flight in which the 6,000, 9,000, and 12,000 meter records were set, the climb angle was 90 degrees. In fact, the airplane actually accelerated through the speed of sound in vertical flight.

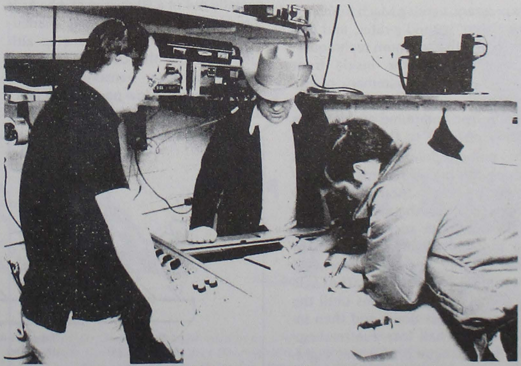
FIGURE 1 – TIME TO CLIMB PROFILE DEVELOPMENT · POWER



HIGH ALTITUDE PROFILES

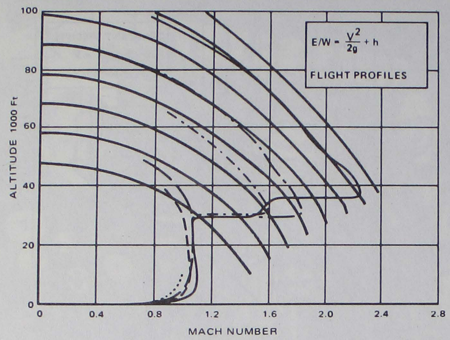
The three higher profiles, which took the airplane beyond its high rate of climb capability, employed an acceleration followed by a zoom climb to reach the record altitudes most quickly, trading off a gain in kinetic energy for higher altitude. We had to find not only the best climb speed, but also the best place (shortest time) to accelerate to the higher kinetic energy level.

Again, the clue is provided by Ps. The initial climb is accomplished at the peaks of Ps, leveling at the altitude where a high level of Ps persists, and accelerating to the speed you want to ▸



The course of each flight was carefully tracked and plotted.

FIGURE 2 – TIME TO CLIMB PROFILE DEVELOPMENT -ENERGY



attain. All of this seems to be fairly straightforward except airplanes do not fly square corners, and the techniques for making turns have a considerable impact on minimum time to altitude. There were three corners to turn on the three higher records:

- The pull after takeoff and low level acceleration.
- Going from vertical flight to horizontal at the acceleration altitude.
- The pull-up into the zoom climb to the record altitude level.

The first step toward solving this aspect of the problem was to use a computer program, varying Mach numbers, climb angles, g's and g-rates, and altitudes to find the optimum techniques. Referring back to the inside front cover, you'll find a summary of the various missions, as flown, and as near the optimized computed profiles as is humanly possible to fly.

The pull-up points for the zoom climb on the higher records were determined by examination of the energy required to attain the given altitudes and the minimum acceptable speeds "over the top." Figure 2 is a plot of specific energy lines, with the F-15 flight profiles superimposed. The Eagle gained energy in the zooms until the engines were shut down and then incurred some small loss due to drag.

The 30,000 meter profile was slightly different from the 20,000 and 25,000 meter flights since there was an additional climb to place the airplane at an altitude where it could achieve the desired energy level without going to excessive levels of dynamic pressure.

Looking again at the chart on the inside front cover, note that the three higher profiles have an Immelmann maneuver after takeoff. The reason for this was to use the winds to best advantage, both on the ground and at altitude. It was desirable to take off *into* the wind and accelerate at altitudes *with* the wind. The Immelmann provided the ideal way of making the 180 degree course correction, especially out of a 90 degree climb. As it turned out, the Immelmann maneuver also provided better time to altitude than did the conventional maneuver because transonic drag is actually lower at low positive load factors than at less than 1.0 g as required for a steep climb.

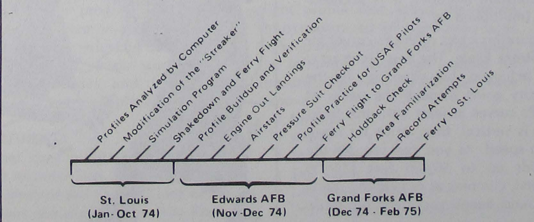
MECHANIZING THE MANEUVERS

Having determined the optimum techniques, we moved from the computer to the McDonnell Air Combat Simulator, where we evaluated the computed techniques from a flyability and pilot workload standpoint. During this phase of the program, emphasis was placed on airplane stability and control "over the top" where indicated airspeeds would be quite low.

The recovery technique arrived at during these tests was to hold flight path angle to a predetermined angle of attack close to that for (L/D) max, and hold that through the record altitude until the aircraft had started downhill and airspeed was increasing.

The simulator proved to be a very valuable tool in assessing the flyability of computerized profiles. In addition, the simulator allowed us to add refinements with the man-in-the loop which we would not have seen through the computer alone. In addition, the experience gained by the pilots flying the simulator greatly reduced the amount of practice flying that would have otherwise been required. On this program, as on so many others during the testing of the Eagle, we heard the same comment by all the pilots, "Gee, that's just like we saw on the simulator."

This gives you an idea of what is involved in preparing for a program to establish world-class time-to-climb records. I've just covered the getting ready; Pete Garrison, McDonnell Chief Experimental Test Pilot, has written a companion article which covers how the records were actually accomplished. Read on, and get Pete's continuation of the story. ■



Project Events

"The Streaker"

By PETE GARRISON/*Chief Experimental Test Pilot*

Eagle Number 17 arrived in the "nest" with a mission stamped "not required." Originally planned as a replacement in the event of an aircraft loss in early flight testing, Lady Luck (and some hard work) decreed that such an event was, happily, not to occur. However, there were some important areas of interest which had not originally been planned in Category I (contractor) testing. Specifically, these included tests of very high altitude stability and control and very high altitude engine characteristics.

In addition, there was an obvious interface between these areas and the fact that three of the world-class time-to-climb records had departed on the wings of a Soviet Foxbat in 1973. After some preliminary spade work, it appeared that all could be wrapped up in the same package, and "Project Streak Eagle" was born.

A great deal of analytical work was done to prepare the "Streaker" (as #17 became affectionately known by her keepers) for the task at hand. My good friend Dick Cahill put a lot of the "smarts" together for this project, and some of his thoughts have been expressed in the preceding article. So I'll not dwell on the technical side, but I would like to chat a bit about the overall program, and then give you some insight from the driver's seat.

TEST PLAN

The overall plan included modification and shakedown of the "Streaker" in St. Louis; flight testing would be accomplished at Edwards AFB, California, and the record attempts would be performed at Grand Forks AFB, North Dakota. The low winter temperatures, minimum air traffic density, and good hangar facilities made Grand Forks a natural.

PLAYERS

This program was indeed a team effort in the true sense of the word. The team responsibilities were basically as follows:

- USAF - Contracting and Project Responsibilities, Record Pilots, Facilities, Chase Aircraft, Weather Detachment, and Airlift.
- MCDONNELL AIRCRAFT COMPANY - Modify Test Aircraft, Define Profiles, Test Fly Profiles and Special Systems, Flight Simulation, Support and Maintain Test Aircraft, and Coordinate Record Certification.
- RCA - Installation and Operation of Certification Radar.
- PRATT AND WHITNEY AIRCRAFT - Engine Technical Support.
- NATIONAL AERONAUTIC ASSOCIATION - On-Site Observers, Assemble and Distribute Results to FAI (Federation Aeronautique Internationale).

MODIFICATIONS

There were no special requirements for this kind of test program since the aircraft and engines had never been in this sort of environment before. Of primary interest was aircraft control with both engines shut down, and subsequent airstarts. This required a large battery package to power the hydraulic and electrical systems. Also of interest was the holdback device which "chained" the "Streaker" to the end of the runway, and was separated by an explosive bolt. The explosive bolt signal also started the official timer in the radar/computer van.

Since the "rules of engagement" for time-to-climb records dictate that the aircraft be made as light as practical, any unnecessary weight was removed. In the "Streaker," this consisted generally of armament removal (the bulk of the weight reduction came from simply downloading the missiles). As Dick Cahill noted, we enjoyed a ten percent weight reduction, even with the addition of special equipment required for the Project (a list of items removed and installed is contained in the preceding article).

The matter of "to paint or not to paint" was resolved in favor of the cost, since the aircraft would have to be repainted prior to delivery. There was also the fact that paint weighs 40 ▸

The satisfaction of successful mission accomplishment is reflected on the faces of Test Pilot Pete Garrison (left), Project Development Engineer Dick Cahill (center), and AFPRO St. Louis Project Coordinator Major Joe Higgs at the final flight debriefing.

to 50 pounds, and "no paint" is in the right direction.

The removal of the Utility hydraulic system reduced the possibility of air entrapment during the long period of near zero 'g' which was anticipated during the high altitude record attempts. (The operation was flawless during the program and lends much credibility to the design of the F-15 system.)

FLYING

I began to follow the program in early 1974 and was fortunate to remain with the program through the first flight, system checkout, profile verification, and record attempts. Of the 62 total flights flown during Project Streak Eagle, about half were flown by McDonnell for profile and system verification, with the balance flown by the three Air Force record pilots.

From the first flight, the "Streaker" was a winner. However, there were many areas we had to explore before we were ready for the actual record attempts.

• **Getting Airborne** - Takeoff from the holdback with stabilized full power was rather spectacular to say the least. The object was to stabilize at full power, burn down to the proper fuel weight, then salute the ground crewman who threw the switch to fire the bolt.

Since there was no tendency to swerve or pitch as the bolt was separated (thanks to some sharp design engineers), the big problem was getting the gear up prior to 300 knots. We finally developed a technique of moving the gear handle up at the same time the stick was started aft. This was done as soon as the pilot saw the airspeed come off the peg at about 80 knots. Our over-the-shoulder camera revealed that by the time the pilot could react and actually get the handle fully up, the aircraft was going through approximately 120 knots at 30 to 40 knots per second.

• **Vertical flights** - Since the computer verified that we needed a 90 degree flight path angle on the lower four records, we decided to use a sensitive g-meter for reference. Instead of trying to use a special gyro system to give us a 90 degree pitch angle, we would pull to 80 degrees pitch on the ADI, then push the aircraft to a nominal 0.2 g and hold that g until radar gave a "recover" call indicating that the record altitude had been reached.

The ADI, of course, does a controlled precession at 90 degrees pitch, and that would occur at about 25,000 feet using this technique. Use of the 0.2 g kept the fuel and engine oil where it belonged and only resulted in about 5 degrees off vertical throughout vertical climbs from the ground to in excess of 45,000 feet. Recovery was then simply a matter of adding back pressure to light buffet and holding that available g to the horizon.


A key part of the project support equipment was the RCA-operated certification radar.

• **Zoom Climbs** - The 15,000 meter profile consisted of rotating after takeoff and holding 55 degrees until a recovery call, rolling inverted, and maintaining a comfortable g to the horizon. The top three were another matter since they required a level flight acceleration and rotation to 55 or 60 degrees and subsequent erect recovery. We found that a 2.5 g Immelmann from takeoff gave a reasonable pilot workload and good, repeatable results.

The computer would have liked a "square" Immelmann with high g's at the corners and a vertical portion between. The high g at the top end gave us problems on repeatability. We wanted to come level at 30,000 feet, and there was no way for the pilot to judge when to start a pullback since the altimeter is pretty much a blur at that time.

After obtaining the proper Mach number on the acceleration, a rotation at 55 to 60 degrees resulted in afterburner rumble at about 65,000 feet which could be reduced by backing off maximum A/B. At about 70,000, the A/B's would tend to blow out and we would then cancel to Military. Depending upon the Mach number, the basic engine would start to unwind at about 80,000 feet and we would go to cut-off on both engines. By that time, holding the climb angle would result in the angle of attack coming up to about 2 degrees true, and the name of the game was simply to keep the angle of attack about 2 degrees, and the sideslip at zero until the horizon showed up out the window. Engine windmill RPM was better than anticipated over the top at 40 to 60 knots indicated airspeed.

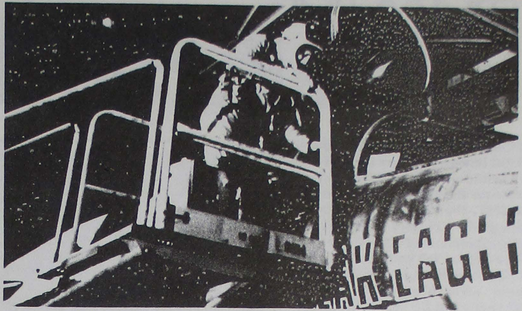
We would hold about zero degrees angle of attack until the nose was down 40 to 60 degrees on the back side. As the airspeed came up toward 400 knots indicated airspeed, we would then reduce the pitch angle to hold about 400 KIAS. At approximately 50,000 feet, boost pump pressure was available from the battery pack, and we would slide both engines to Idle. In most cases we would have them running and be level at about 35,000 feet. On a few occasions, one or the other would stagnate and require another shutdown and restart, but we always got at least one on the first try. Recovery was then simply a return to high key with about 1,000 pounds of fuel remaining.

• **Engine-Out Landings** - Although we had complete confidence in the engine restart capability, we sized our battery-driven system to allow for an engine-out recovery if the worst should happen. In order to obtain good handling/sink rate information on the engine at low altitude, we performed actual engine-out landings at Edwards AFB. We discovered that a significant difference existed between engines at Idle and engines off. Fortunately, the instinctive pilot judgment tended to be better with engines off than with engines at Idle. Idle power tended to force the landing long. We also verified that the engines very rapidly spool down to zero RPM when shut down at low altitude and pattern airspeeds.

• **Pressure Suit** - It was necessary that we utilize full pressure suits for all four of the top records since they resulted in altitudes above 50,000 feet. On our buildup flights and profile practice, we simple separated the zoom climbs so that we could take off and check out the pressure suit at our leisure. However, on the actual record flights the suit had to be carefully checked prior to takeoff since there was no time to accomplish it during a record run.

While conducting the buildup flights we once again proved the value of "no flights above 50,000 without a suit." The game plan indicated that even with engine shutdown at 70,000, the cockpit leak rate which we had in the "Streaker" should allow us to get over 100,000 feet and back to 37,000 before the cockpit went above 37,000 (the suit holds at 37,000 feet). Armed with this information, I pressed our zoom climb profile up toward 50 degrees from Mach 2+ rotation at 35,000 feet. (Once high climb angles have been established at high Mach numbers, the pilot is just along for the ride. There is no way to stop the elevator without getting well in excess of 70,000 feet.)

I went over the top with a fully pressurized suit! Needless to say, I was a bit concerned, particularly since no problem could be found in the pressurization system after landing. This was really the only chronic problem we had to face. It required more flights and other tests before we resolved the problem as one of canopy flexure which allowed pressure leaks under certain high speed, high altitude conditions. Since the problem existed in other F-15's, the solution will be incorporated in production.



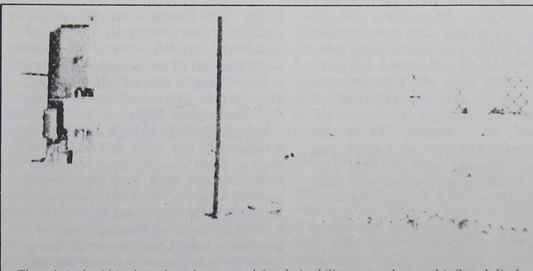
Full pressure suits were required for all flights over 50,000 feet.

IN CONCLUSION

The successful completion of this program is a tribute to the teamwork between the aviation industry and the United States Air Force. We learned a great deal about the Eagle, and I'm sure some of the benefits will be coming your way.

You may remember what Irv Burrows wrote about TF-2 in his conclusion to the "Fast Pack" story — something like the airplane going right back to work and there being no prima donnas among Eagles. Well, the Streaker is a "worker" too; right now it's in demodification here in St. Louis, and quite possibly will find its way into one of the tactical squadrons.

There were no irreversible modifications made to the Streaker; in fact, the engines have been returned to the test program for use in other F-15 aircraft. Despite the changes and modifications in the Streaker, we feel that this 17th F-15 to roll off the McDonnell production lines was essentially representative of the airplanes you'll be flying day-to-day. While you may never have the opportunity to approach the extreme altitudes or use the exact profiles we developed at Grand Forks, the potential is inherent in every Eagle. ■



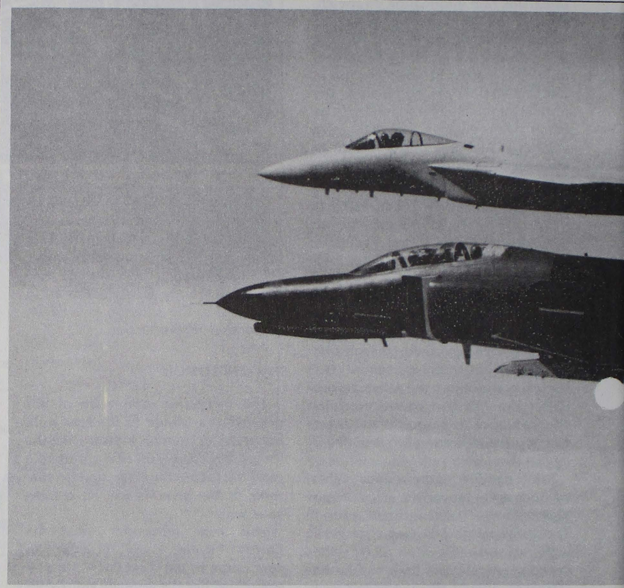
Though jackrabbits have long been noted for their ability to accelerate, this Streak Eagle spectator found himself a poor second to the record-setting F-15.

(1975)

PRODUCTION FLIGHT TESTING...

Company and customer pre-production flight testing activities on the F-15 have been pretty thoroughly documented over the past couple years in the DIGEST. We kept you up-to-date all through the Category I program at Edwards, summarized Cat II status, and hope to soon tell you a little about the JTF concurrent tests at Luke. And, of course, we've been writing about F-4 flight activities for years. But there is another important and interesting side to the flight testing story that we have never touched upon before and which may be much less familiar to you squadron pilots — the check and acceptance flights performed on production airplanes.

One of the major responsibilities of McDonnell Aircraft Company's Flight Operations Department is to thoroughly wring out every airplane manufactured here in St. Louis, before it is approved for release to the customer. Chief Production Test Pilot E. D. Francis currently utilizes the services of ten other test pilots and five systems operators in these evaluations of Eagles and Phantoms. Here is a brief look at what they do . . .



Ever wonder what your airplane has been through before you as a ferry pilot or as a squadron pilot first climb into it? If so, and now that we are delivering production copies of both the Phantom and the Eagle, maybe I can shed some light for the curious.

There's a famous auto manufacturer who advertises a thousand inspections before he lets a car off the assembly line. I don't have the slightest idea how many separate inspections an F-4 or an F-15 gets before it's okayed for flyaway, but I suspect it's several thousand more than that little bug receives. Anyway, here in Flight Test we're primarily concerned with how well all those other inspections have "put the product together," and I guess you might call us the *"final inspectors"* in a sense!

For us, the first, and probably biggest task is getting the great quantities of required documentation, local letters of agreement with the Tower and Center FAA personnel, clearances, etc., wherein weight of paperwork equals weight of airplane. Since this part of the program is about as interesting to you as it is to us, I'll slip right on by it and into an Eagle first and second flight.

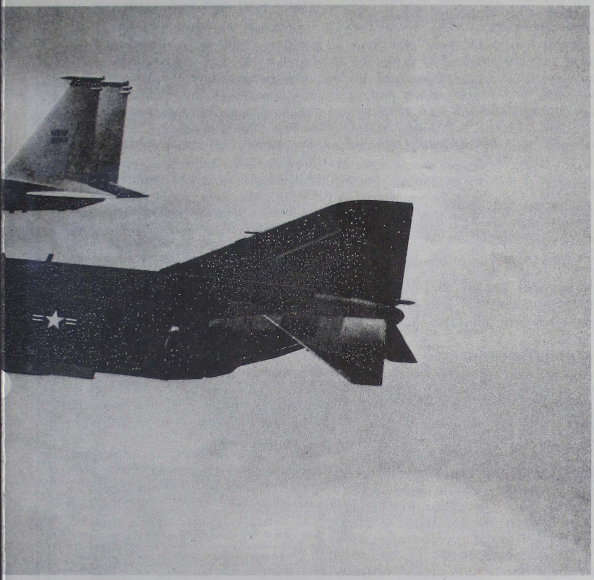
We generally go to high altitude for a supersonic run, with any additional engine, flight control, avionics, autopilot, airspeed/AOA, etc., type checks we may have fuel for before returning for an ILS full-stop landing.With the F-15 supersonic run completed, we generally hang two external wing tanks for subsequent avionics testing, generally done 15,000 feet and below (the F-4 stays clean for additional flights). When the safety of flight and major subsystem writeups are corrected, we turn the airplane over to the local USAF Flight Office. AFPRO pilots perform basically the same checks until they decide the vehicle is ready for delivery. That's when you "buy" the airplane and enter the picture for what we hope is a long and pleasant association with another new McDonnell product. Now let me go back for a few details on some of the things we look for (my discussion will flip back and forth between Eagle and Phantom and I hope it doesn't get too confused)-

PRESTART

I try to check as much as possible before starting engines, obviously to

By DEE FRANCIS/*Chief Production Test Pilot*

PHANTOM & EAGLE



save fuel. After both engines are started, I'll begin INS alignment (first flight is usually made with no external A/C power for start in order to check emergency and normal generator switching). By using the mirrors in either airplane, I can watch the control surfaces for correct movement and finish the control checks faster than the flight ramp inspector (our civilian version of the crew chief/plane captain) can call out the movement.

On the F-15, after the engines are going, I like to check takeoff trim and PTC first with CAS Off; make the four corners check for correct ARI rudder inputs; and check that ARI can be cut out by anti-skid, pitch, and roll ratio switches. Aileron washout when roll ratio is cycled is next and then CAS On checks are made. Manual rudder input, yaw CAS On, gives 30 degrees of rudder, while turning yaw CAS Off reduces it to 15 degrees. Next I'll deflect the aileron with slight aft stick and watch for slight increase in rudder deflection from ARI as flaps are lowered.

(Of course, all of these checks are not on the checklist and would not be required in daily squadron use, but for our type of flying and for first flights, they give a good look at the components of the flight control system.)

I'll next cycle the bleed switch to the individual engine and have the inspector see that flow through the ejector valves matches the switch setting. Flow into the cockpit is no clue here as the cockpit receives air ahead of the ejector valves. Next I'll cycle the EEC switches and have nozzle cycle verified. The gage can show nozzle movement without the nozzle moving due to the location of the pickup for the indicator.

Then follows all the normal turn-on of avionics and functional checks of temperature control, spedbrakes, slipway, HUD, lights, etc. After the INS alignment is complete, I go INS and taxi out.

ENGINE RUNS

I make stabilized Military power runs and min AB lights in our ramp runup area. If these checks are good, it's out the gate for the runway and a look at normal and anti-skid braking, emergency brakes, and steering while taxiing. F-4 checks are just to Military and are made on the runway.

TAKEOFF AND CLIMB

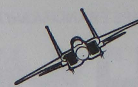
I use Military or AB as desired and climb to the altitude agreed upon with the FAA. (F-4 takeoffs are all in AB.) Since gear and flap operation, pressurization, fuel transfer, instruments, and com-nav gear are so basic to every flight, I won't go specifically into them.

Phantom first flights are slightly different from the F-15 in that generally two radar 90 degree intercepts are performed as well as auto-acquisition, boresight, gunsight checks, and setup of TISEO before leaving the target for an individual supersonic run. Eagle radar checks on first flight are generally against any available airliners, but sometimes one beam pass is made with F-4's.

SUPERSONIC RUN

With the Eagle, I light the burners and just hang on! The F-15's acceleration to 1.6 still dazzles me. Unlike the F-4, you are supersonic by the time both AB's stabilize. Engine and inlet operation are the main items I watch to approximately Mach 2.0, but the rudder limiter is checked while accelerating. The rpm lockup at ▸

PRODUCTION FLIGHT TESTING



Military after AB is cancelled must be verified as well during the deceleration.

(At high mach, we sometimes see the bypass doors opening, which seems to slow the rate of acceleration to top speed. After several high mach runs, it becomes apparent that the F100 engine is very sensitive to temperature, seemingly more so than with straight turbojet engines. In our F-4K's and M's for the United Kingdom, with Rolls Royce Spey engines similar to the F100, the same point was observed above about Mach 1.7 when compared to the other F-4's we were flying at the same time. Then, on a warm day, the only speed you gained near Vmax was due to the weight reduction of the fuel being burned.)

With the F-4, which now has the drag from the slat actuators, strike cameras, and TISEO stub, we usually ask FAA for a push-over in order to reach 710 knots, its maximum CAS above 30,000 feet, especially since we now check the slat airspeed switch at approximately 600 knots (extend them manually about 570 and it feels like a speedbrake). Earlier F-4's generally required no push-over. With both airplanes, after becoming subsonic again, engine and afterburner checks (and in the F-4, slat audio checks) are made, usually during a windup descent.

SYSTEMS CHECKS

Once below PCA, plus & minus G autopilot cutout checks, airstarts, cabin pressure dump and reset, and gunsight checks are similar on both aircraft. With the F-15, we have four preset programs in the ACS panel, and numerous INS IP's and offset targets stored for the local St. Louis area. With the WRCS F-4, we use several of the same IP's and offset targets. These have been selected in several different locations around St. Louis for the days that weather has one area socked in.

Of course, with the Eagle, you can designate any convenient target with the INS and select Auto, CDIP, or Direct mode and check the HUD steering, all the while trying to avoid the farmhouses, mink farms, and turkey ranches. But with both aircraft, these are only functional checks. You guys get the real fun of actually shooting and dropping things for score.

Airspeed vs AOA, gear and flaps down, and the airspeed switches are next, and that's usually about all we have fuel for. Our airport is now a TCA, with resulting IFR type handling. The old days of hitting initial approach with 2,000 pounds remaining are gone forever.

LANDING

As mentioned earlier, most of us make an ILS in the F-15, looking at the various steering signals on the HUD, ADI, and HSI, and using more INS steering information. Since the nose can be held up on the Eagle, we usually land that way and check the anti-skid when the nose is on the ground.

With the F-4, on first flight I will jump on full anti-skid right after the chute is out. Seems as if it requires hard stops like this for a flight or two before the brakes "burn in" or "set." The relief does vary from airplane to airplane, but when I can stop in 2500 to 3000 feet, I can't fault the anti-skid too much, especially at the speeds we land with slats. There are those days where I leave an airplane on the taxi-way with a red face on me and two blown mains on it, but luckily those days don't come up too often.

SUBSEQUENT FLIGHTS

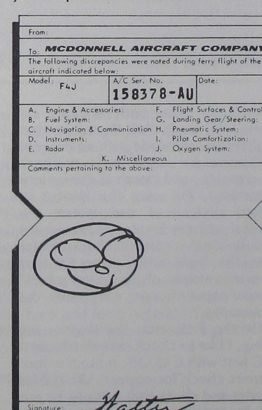
Supersonic work completed, as mentioned above, the full radar checkout commences on the F-15. With the detection and lock-on ranges the radar is capable of, we start out around 100 miles apart for head-on look-up/look-down LRS and VS checks, as well as AAI. We also make tail-on look-down passes, as well as supersearch and boresight lock-ons. After the air-to-air is completed, the various air-to-ground checks are made. Since the Dash 34 covers the modes in detail, I won't go into them here.

F-4 subsequent flights generally clear up unfinished items from first flight and check the previous writeup items. This may mean more radar or even another mach run, but not always. A really clean Phantom may be on its third flight when you ferry it away.

WHEN YOU GET THE AIRPLANE

Although I've left out a lot of the details we look at on production test flights, you can figure that every number, pressure, or AOA reading mentioned in the Flight Manuals was checked to company/customer satisfaction. Then how come, I can already hear some of you ferry pilots saying, things can go wrong and cause aborts on flyaway or problems along the way?

I guess I can only answer that that's the nature of the complex beast. Avionics for example, can work perfectly on one flight and be completely inoperative the next time you turn it on. And that's why every airplane comes packed with a "Ferry Flight Discrepancy Card" for you to shoot back to us if you're not pleased with the product. Several years ago, Commander Joe Walter sent back the card below after an F-4J ferry to Miramar. We like that kind of report, but if you land looking like this - ☹, give us *those* reports too. When everything is working as advertised, we think the F-4 and the F-15 are both great airplanes and we want you to be just as pleased as we are. ■


From:

To: **MCDONNELL AIRCRAFT COMPANY**

The following discrepancies were noted during ferry flight of the aircraft indicated below:

Model:	A/C Ser. No.	Date:
F4J	158378-AU	

A. Engine & Accessories:
B. Fuel System:
C. Navigation & Communication
D. Instruments:
E. Radar
F. Flight Surfaces & Controls
G. Landing Gear/Steering:
H. Pneumatic System:
I. Pilot Comfortization:
J. Oxygen System:
K. Miscellaneous

Comments pertaining to the above:

Signature:

(1975)

"Not a Pound for Air-to-Ground!"

By DON STUCK/*Advanced Design Project Engineer*

Way back in the design stages of the Eagle, the expression "not a pound for air-to-ground" was born. There's an interesting story [which I am about to tell you] behind that catchy phrase, and behind the airplane that is maturing today [which you are seeing for yourselves].

The name of the game for the F-15 engineering design team was to produce a fighter aircraft totally optimized for air superiority with absolutely no compromise of that primary aim. Among the more obvious required attributes were maximum power and maneuvering capability with minimum weight and complexity. Because of an unyielding resistance to adding weight or complexity, you have what we think is the finest air-superiority machine that has ever come down the pike - better than anything you'll be seeing for a long time to come, in your sky or someone else's. But let's talk here about how the F-15 also developed into an impressive multi-mission vehicle.

Each time the multi-mission "attackers" stormed the Project Design castle with features to enhance air-to-ground or other capabilities, the air superiority "defenders" met and repulsed them with a resounding "not a pound for air-to-ground!" So how did the air-to-air superiority Eagle end up with a secondary but fully viable air-to-ground capability?

Simply said - when the A/G troops found they couldn't beat 'em, they joined 'em! They plotted a strategy which would flank the entire line-of-resistance to A/G features. Their key was to "help" design A/A equipment so that it could be used for A/G with no compromise in weight or primary mission and to assure that any features needed for A/G also enhanced air superiority.

More simply said than done. While the theory was simple, the practice involved an extraordinary amount of time, coordination, and gnashing of teeth. It is beyond the purpose of my story here to detail any of the day-by-day

DO-IT-YOURSELF WEAPONS PLATFORM. We're showing a clean F-15 here so as not to limit your imagination with respect to variety and arrangement of items to hang under this airplane. No matter what you may have in mind, be it A/A, A/G, intercept, reconnaissance or surveillance, there's a place for it on the Eagle. Several configuration possibilities are ranged in formation across the page, and the photo on page 70 shows a typical weapons load.

effort expended - suffice to say that the result was worth every ounce of it in that the Eagle offers an air-to-ground capability matching or exceeding performance of fully dedicated attack aircraft, with no compromise of its air superiority role.

ADAPTABLILTY

Developed as an uncompromised air superiority fighter, the F-15 contains the structural ruggedness, flight characteristics, survivability features, and equipment essential for the attack mission without modification. Using knowledge gained from the F-4 in combat, with particular emphasis on survivability in sophisticated defense environments, the F-15 has been designed to penetrate enemy defenses and return home safely.

The existing F-15 provides a capability to deliver unguided weapons with the accuracy required to assure destruction of targets with minimum bombs and sorties. Hardpoints designed for external tanks are also used to carry bombs without removing any air-to-air weapons. Over 15,000 pounds of air-to-ground ordnance can be carried on 18 qualified store stations in addition to four Sparrow and four Sidewinder air-to-air missiles, two ECM pods, and the internally-mounted 20 mm cannon.

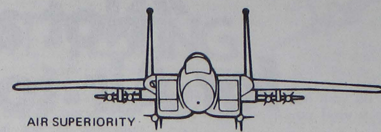
Advanced avionic systems necessary for missile and gun computations and displays are also used on attack missions to compute bomb release data and simplify the pilot's job so that he can deliver weapons with extreme accuracy. The F-15 further possesses the potential to utilize the latest in the family of guided air-to-ground weapons, still without losing any air-to-air capability.

MISSION CAPABILITY

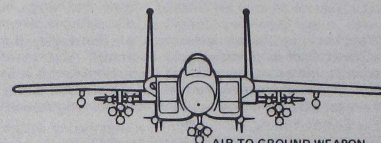
Flight characteristics that make the Eagle an outstanding air superiority aircraft lend themselves readily to the attack arena. The aircraft's performance margin, low wing loading, and highly responsive flight control system enable it to avoid enemy defenses while maneuvering to put the bombs on target. Its armament carrying capacity, combined with a rapid turnaround capability, assures maximum tonnage on the target with the minimum number of missions and aircraft. The stable delivery platform provided by the airplane and its proven avionics suite assures bombing accuracy superior to that demonstrated by current dedicated air-to-ground aircraft.

Greater operational mission coverage is possible with the fast-reaction Eagle, which can be airborne literally within minutes of initial notification. Upon return from a mission, the airplane is equally agile with the capability of being turned around with fuel, ammunition, oxygen, ground inspection, and a full ordnance load of up to 18 MK-82 bombs in less than 30 minutes (it's been done in 18). The F-15's long reach assures the capability of delivering meaningful ordnance on distant targets or remaining on station for extended periods of close air support. With a normal close air support load, it is capable of providing up to 2.5 times the loiter capability of the CAS standard of Southeast Asia, the F-4.

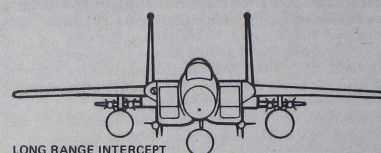
Because of the long range capability of the basic F-15 and its natural fuel growth modifications, much of the potential target coverage is attainable from basing deep within friendly territory, thus demonstrating the possibility of reduced basing and support in addition to increased operational versatility. As an example of fuel/range efficiency, the F-15 with six MK-82 bombs and four AIM-9 missiles has a radius of 655 nm. If fuel pallets (high-volume, low-drag conformal shapes fitted against the



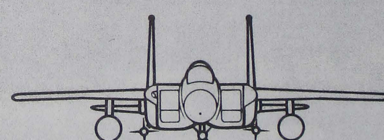
AIR SUPERIORITY



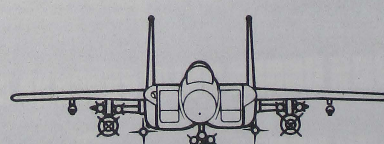
AIR-TO-GROUND WEAPON DELIVERY WITH SELF DEFENSE



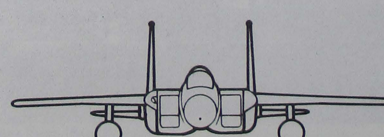
LONG RANGE INTERCEPT OR COMBAT AIR PATROL



ADVANCED INTERCEPTER



EXPANDED AIR-TO-GROUND CAPABILITY



ADVANCED RECONNAISSANCE

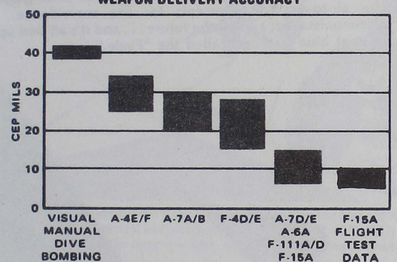
▸

fuselage just under the wing) are added, with the same weapon load the radius increases to 1059 nm. For close air support at 100 nm, the airplane is capable of loitering with 12 MK-82's for approximately 1.4 hours. With fuel pallets, the loiter time is doubled. The Counter-Air mission also illustrates F-15 range potential with large payloads of general purpose or guided bombs; it is capable of carrying two MK-84 LGB bombs to 644 nm, and to 1026 nm with fuel pallets - comparing favorably to the 368 nm capability of the F-4.

WEAPON DELIVERY

The purpose of an attack aircraft is to put the bombs on the target. In most aircraft, maximum accuracy is obtained by tracking the target in a wings-level attitude that provides a constant flight path. Although wings level tracking is not particularly dangerous in a low threat area, most targets worth hitting from the air are also worth defending from the ground. This necessitates a constantly

WEAPON DELIVERY ACCURACY



changing flight path to avoid taking a hit. In most aircraft on combat missions, the pilot must decide how much of his accuracy he wants to trade off for survivability . . . not so in the F-15. The Eagle's computed bombing modes have been designed to let the pilot perform evasive maneuvers of his choice (except a 180 for home) up until the instant before bomb release, without compromising his accuracy.

The results of the Contractor and Air Force flight test programs proved the high degree of accuracy of the F-15 weapon delivery system. Category II tests conducted by the Air Force resulted in an overall average accuracy equivalent to an average miss distance of 75 feet with a bomb released at 10,000 feet range in a 45° dive. Testing also included accurate bomb drops from 15,000 to 19,000 feet range, a feat not even feasible in many attack aircraft. The results of this testing showed that the Eagle can deliver bombs under these conditions within an average error of less than 100 feet.

The F-15's weapon delivery system provides five different modes of bomb delivery:

- Automatic (Auto) Mode provides computed ballistics that do not limit the pilot to specific delivery parameters. The pilot is only required to designate the target, hold the weapon release button depressed, and null the azimuth steering error before reaching the weapons release point. Weapons can be released from dive, level, or toss conditions. Weapons release is initiated automatically when the range to the desired weapon impact point equals the computed weapon down-range travel.

- Continuously Displayed Impact Point (CDIP) Mode is a computed, manually initiated release mode. The pilot flys the reticle aiming dot (which continuously indicates the ground impact point of the weapon) over the target and manually initiates release with the weapon release button.

- Guided Weapon Mode - Whenever Electro-Optical (EO) or Infrared (IR) guided weapons are selected on the Armament Control panel, a manual release mode is activated to aid the pilot in acquiring the target and achieving lock-on prior to release. The Head-Up Display reticle is slaved to the weapon seeker head so that the pilot need only put the reticle aiming dot on the target, uncage the seeker head, and release the bomb. On Electro-Optical bomb deliveries, the weapon seeker head video is displayed to the pilot. The laser guided weapon is delivered in the same manner as conventional bombs using the Auto, CDIP, or Direct mode.

- Direct and Manual Modes are backup modes to provide a "canned" delivery. The Direct mode requires that the HUD depressed reticle be placed over the target while meeting predetermined air speed, altitude, and dive angle conditions. Included on the reticle is a slant range bar that will increase bombing accuracy over terrain of unknown elevation. Release is manually initiated with interval, quantity, and sequence commanded from the Armament Control Set. The Manual mode is an extension of the Direct mode, assuming an inoperative ACS where the pilot must depress the weapon release button for each release.

SURVIVABILITY

With the advent of multiple threat defense systems facing attack aircraft, the F-15's performance characteristics are particularly noteworthy. Attack aircraft are required to carry their bombs through rings of surface-to-air missiles, anti-aircraft fire, and enemy aircraft in order to reach the target and return home. Pilots, experienced with this hostile environment, have described ingress and egress maneuvers as "air-to-ground dogfights." Barrages from missiles and AAA batteries require constant hard turns to avoid destruction.

Throughout the development of the F-15, good survivability/vulnerability design practices were used with special attention given to redundancy, separation, concealment, and protection. Of particular importance is redundancy, which pays off in other areas such as mission success and safety. The slightly higher maintenance requirements and costs of redundant systems are more than offset by the advantages they provide. An example of this can be seen in studies of nearly equivalent single and twin engine fighters where survivability of the twin engine design is 33% greater than for the single engine design. The operational cost savings associated with this increased survivability more than compensate for the higher costs of the basic design.

The efficient sizing of the F-15 was predicated on the smallest possible shape commensurate with operational effectiveness and survivability. Internal mounting of a fully integrated tactical electronic warfare system (TEWS) was considered of prime importance to provide warning characteristics not available to smaller installations or pod mounted units. The F-15 TEWS enhances survivability by providing both threat warning and automatic countermeasures against selected threats.

The internally mounted F-15 equipment is capable of automatically tuning the ICS frequency and concentrating jamming power on the exact output of the threat, thereby achieving maximum jamming effectiveness. This characteristic, denied less sophisticated smaller units, allows many times more power density than smaller units to be brought to bear against an individual target. High survivability is, to a large part, due to the internal countermeasure (jamming) equipment capability to increase the threat missile miss distance beyond its warhead lethal radius.

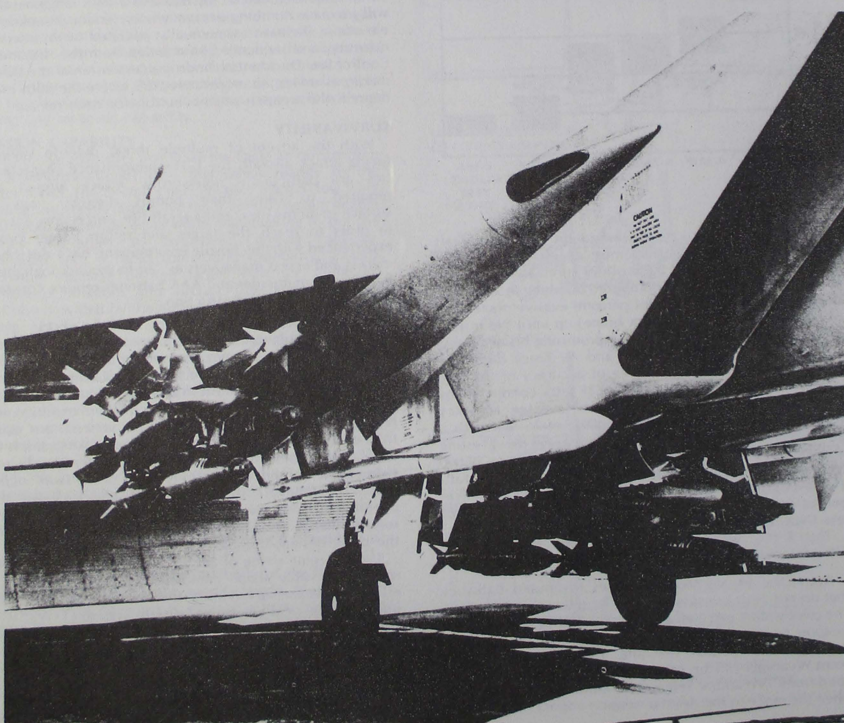
VERSATILITY

The inherent capabilities of the versatile F-15, plus its easily achieved growth potential, make it a leading candidate for many missions in addition to air superiority and attack. Utilizing experience from the growth and longevity of the very successful F-4 aircraft, the F-15 was designed to grow with advancements in system technology and state of the art as they developed. Such growth potential is denied a fully utilized airframe of smaller size.

Growth possibilities for the F-15 can even further increase its mission effectiveness or expand its capabilities to new missions. Fifty percent unused internal volume, 96% unused electrical capacity, and 20% unused cooling capacity is available for over 4,000 pounds of added internal fuel or additional avionics. The central computer, which controls and coordinates the avionic systems, contains over 100% growth capacity for additional capability.

Additional air-to-ground ordnance, such as Maverick and EOGB/MGGB bombs, may be carried with minor modifications to the weapon delivery system. Air-to-ground ordnance capacity has been projected to 25,000 pounds of ordnance weight carried from 29 store stations. Changes to the F-15's weapon delivery system are accomplished easily because all avionics are digital. Additions to the weapon inventory require only a simple reprogramming of the computer to accept new armament instead of a major change in aircraft hardware.

Nobody uses the catch phrase "not a pound for air-to-ground" these days. Every pound is for air-to-ground; for air-to-air; for intercept; for sea surveillance; for reconnaissance; and for the future . . . and it's all tied up in a neat blue package called the "Eagle." ■



FIGHTER PILOTS VIEW F-15

(Reprinted from Bitburg AB "Skyblazer," issue of 27 April 1977)

Brigadier General Fred Kyler — "Eagle One" of the 36th TFW, addresses visitors to Bitburg's reception for first squadron of F-15s in USAFE. The general had just deplaned from Eagle 76-008 after 6 1/2 hour nonstop flight from Langley AFB in vanguard of 23 aircraft mass flight. In an earlier interview, Gen. Kyler and other wing crewmen had commented on F-15 capabilities.

"It's the easiest flying aircraft I've ever flown. You fly it down to the ground and round it out - it'll float a little bit then land. Without any doubt it's the easiest plane I've ever flown."

Those words spoken by Brig. Gen. Frederick C. Kyler, Wing Commander, are just a few of the many outstanding statements directed toward Bitburg's newest addition - the F-15.

Maj. Charles Price, another F-15 pilot, says, "they oversimplify it when they claim that you can fly with your feet on the floor; but you don't really have to be concerned with rudder in the plane. To get a faster roll rate you might want to put more rudder in, but it's not required. The airplane takes care of the flight control integration itself."

"It's the most maneuverable aircraft I've ever flown and that we have today - including the other team's to the best of my knowledge," commented Gen. Kyler. "When I say the other team, I'm talking about the other side of the Iron Curtain," Kyler further explained.

Bitburg's last fighter was the F-4 Phantom, another McDonnell Douglas airplane designed to handle some air-to-air combat missions. With a capability of delivering nuclear weapons as well as conventional weapons, the F-4 has found its air-to-air role overshadowed by the inception of the sleek "Eagle."

The F-4 is still a fine airplane. "None of us would mind going to war in it," noted the general "but it's kind of nice to have the F-15 with its tremendous capabilities compared to anything else in the world."

There are a number of reasons why the Eagle is the best air-to-air fighter aircraft in the world today.

SSgt Dave Danner, OMS crew chief, feels the primary reason is maintenance.

"On the F-15 you can accomplish a lot more in a lot less time because of the various systems and the way they put the airplane together. The crew chief's job isn't half as difficult as with the Phantom.

"The preflight isn't as involved either. When you're inspecting one of the hydraulics systems for instance everything is in a foot and a half area. That makes it a lot easier since there are not nearly as many panels to open as on the Phantom."

General Kyler can't say enough good things about his plane.

"It's an honest aircraft," he beams, "its handling capabilities are such that it is a pleasure to fly. Being an old guy like I am, I can speak with authority as far as being able to compare planes and tell you what impresses me." ■

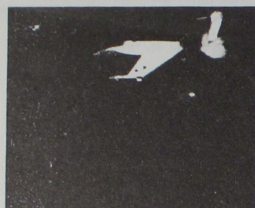
THANK YOU! Many individuals and organizations provided information and materials for this special report on introduction of the Eagle to Europe. Our appreciation is expressed to 1st TFW Information Office and Major John Alexander; 36th TFW Information Office and Captain Geoff Baker; staffs of Langley AFB newspaper THE FLYER and Bitburg AB SKYBLAZER; photographer Kenneth Silver of the Newport News, Virginia DAILY PRESS (outside front cover photo); USAF photographers TSgt Bob Tirado, SSgt Emmett Lewis, and Georg Wegemann (and others we unfortunately were unable to identify). And a special thanks to MCAIR Rep-in-Charge at Bitburg, Art Hyde and SKYBLAZER editor, Sgt Bob Waggoner for all of their extra-special services.

(1977)

Simulation is Alive and Well

By LARRY ROSS
Laboratory Unit Chief, F-18 Simulation

POINT AND



Frequently, an article in the DIGEST draws considerable comment from our military readers. Maybe because it was a goof, gaffe, or gotcha. But just as often because the subject really "hit home" for somebody. Sometimes we get these latter comments by phone; sometimes by a short note . . . and once in a great while by a well-written, thoughtful, and thought-provoking letter.

Here is such a letter, and the response it elicited from two MCAIR people who should know - from engineer Larry Ross (an ex-Air Force fighter pilot and the author of the article which drew USAF Lieutenant Colonel Walt Bjorneby's original comment); and from one-time company test pilot Pete Garrison (who as a military/contractor aviator has already flown the same "routes" now being traveled by the colonel).

Colonel Bjorneby is quite right about the poor flying characteristics of training simulators in the past and unfortunately, this is probably still true of some of the current generation of trainers (my Air Force experience ends with the F-106 so I have only hearsay knowledge of some of the more recent "blue boxes"). This unhappy situation is partly the result of the analog computer technology that formed the basis for most of the early trainers; partly due to the lack of accurate aerodynamic models of the vehicles to be simulated; and partly because of lack of suitable "operational environment" acceptance test criteria.

The first problem has largely been overcome by the coming of age of digital computers and solid state electronics (although new gremlins such as "transport lags" and "iteration rates" must now be dealt with). The capability to develop rigorous models of aerodynamic and flight control systems is also now available but sometimes suffers in the "translation" of data from airframe designer to trainer designer. This is partly because the prime contractor is usually required to provide models well before flight testing is complete; and therefore, they are based on wind tunnel testing and may contain a substantial amount of engineering extrapolations and estimates.

Thus, as the colonel points out so correctly, pilots have had to learn to fly the training simulators and the same techniques have not always been transferable to the aircraft. Pilots must learn to fly our simulators, too; however, this training is primarily required for the aircrew to learn to use the visual cueing of the simulator in

(Continued on Page 74)

Mr. Nade Peters
Editor, Product Support Digest
McDonnell Aircraft Co.
P.O. Box 516
St. Louis, Mo. 63166

Dear Mr. Peters:

We just received your (first) issue of 1977 and, as usual I grabbed a copy and sat down to read it from cover to cover to bone up on the F-4 and study the F-15. The article on Flight Simulation started me thinking when Mr. Larry Ross stated that, "In a very real sense, we no longer try to build the simulator to fly like the aircraft - we build the aircraft to fly like the simulator."

I am sure you are aware that for many years pilots have been saying of simulators - "If the bird flew like that I'd quit in a minute"; or, "Why can't they build simulators that fly like airplanes?" The old 'sims' were mostly analog devices, and consequently had to put up with machine lag appropriate enough for a big airplane but quite unlike a fighter in dynamic response time. In addition, most mathematical models derived the displayed error from the rate of the applied input as well as the amount. This led to and reinforced an artificial way of flying (the deliberate, slow correction of perceived errors in order to compensate for the faults of the mathematical model mechanized in the simulator) that turned out to be a good technique for instrument flying but not at all suitable for formation flying. The newer, digitized simulators were an improvement but still not the same to the pilot. The crews still must learn both "real aircraft" and "sim" techniques in order to achieve optimum results.

After thinking about this for some few minutes I realized that of all the fighter aircraft built in recent history only two have ever been revered by their pilots as being "pilot's aircraft" - the Spitfire and the F86A-F series. I never got to fly a Spitfire but I sure did fly the Sabre, and I agree with Wing Commander Johnnie Johnson in his book on air combat entitled, "Full Circle" - the Sabre was delightful to fly and its dynamic response matched the pilot superbly. I have since flown the T-33 (of course), the F-102, F-104A, and F-4D and E (non-LES) and remember that each of them, more or less, had to be herded about the sky. The 86 was like a good cow pony; it did what you wanted it to do, just so, and no more... the rest all over- or under-shot and required constant correction.

The reason, I believe, is because the dynamic response of the 86, due to a happy combination of aerodynamic and inertial moments, matched the time constant of the average pilot's reflex arcs - as he realized the need for an input the aircraft had just responded to the previous command and had stabilized in that position. In the close-in air combat game, when your reflexes and your aircraft response must beat

COUNTERPOINT

At first, because of the length of his letter, we were going to print only excerpts, but couldn't decide what to leave out! So this is the whole bit. Everything Colonel Bjorneby says, while sharp and perhaps a bit discomforting to some of us in the business, is relevant and rational, and may well represent the feelings of a lot of you jet drivers regarding this complicated combination of flight simulators and (or versus) the "real world." We know the replies by Larry and Pete represent the feelings of McDonnell Aircraft Company. Therefore, we hope this informal discussion by three people obviously interested and knowledgeable in the whole situation will equally interest you. Their observations on the problems and possibilities surrounding the concept offer you a new look at some of the art and science behind flight simulation today.

that of your opponent, the perception-reflex reaction arc is crucial to a successful outcome. One's mind becomes a "monitor", not a conscious actor in the flight; training, reflex, and instinct guide your motions; and any lag or over-shoot because your aircraft does not interface with you becomes a negative influence.

The Century series are beasts in this area because of the long moment arms; and I believe that in a close-in fight an F-4D would have an advantage over a hard-wing F-4E because of the difference in longitudinal inertial moment; the D is noticeably more responsive in pitch. Likewise the F-104 was one of the quickest aircraft in and out of a roll that I have ever flown - so long as you stayed out of coupling, that is.

As a practical application of all the above, may I suggest that in your new advanced maneuvering aircraft you consider matching the aircraft to the pilots. It will (through design requirements) have lessened aerodynamic and inertial moment arms. The concentration of lifting area about the center of the craft; plus the concentration of fuel, engines, equipment, and so forth; plus the control-configured design requiring a fly-by-wire control system all combine to make it most feasible to incorporate a system response matching that of our average fighter pilot. The pilot's inputs will go into the same computer that will keep the bird going in the desired direction - why not make sure that the machine responds the way the man anticipated that it will? By doing this, pilots will be able to get the most out of the bird; there will be no "lost motion" or unnecessary corrective inputs; both new guy and old head will derive benefit as each will reach his ability peak more quickly; and last, but certainly not least, the aircraft will become as legendary among fighter pilots as the Spitfire and the Sabre.

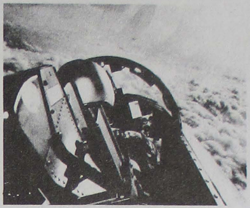
This couldn't be done before, as long as design limitations forced long skinny airplanes on us, or airplanes with weights hanging on each end, plus the added problems from kluging up a conventional control system to where one could keep the beast under control at the ends of the flight envelope. But control-figured vehicles with digital computer adaptive autopilots using fly-by-wire inputs can adopt about any dynamic time constant desired - please pick one that matches the pilot!

This entire idea, concept, dream (if you will) of an old but still bold fighter pilot is offered free for the purpose of getting the best possible fighters for the USA.

Walter Bjorneby, Lt Col USAF
Homestead AFB, Florida

Sabre of the Seventies

By PETE GARRISON
Branch Chief-Design



Engineers call it "man-machine interface"; the younger tigers speak with much wisdom on the black arts of control augmentation, feedback loops, and angles-of-attack; but the "old head" (on the shady side of forty) more and more tends to bend his arm, expertly rattle his glass for the waiter and, with a faraway look in his eye, slip back into the "days of the Sabre."

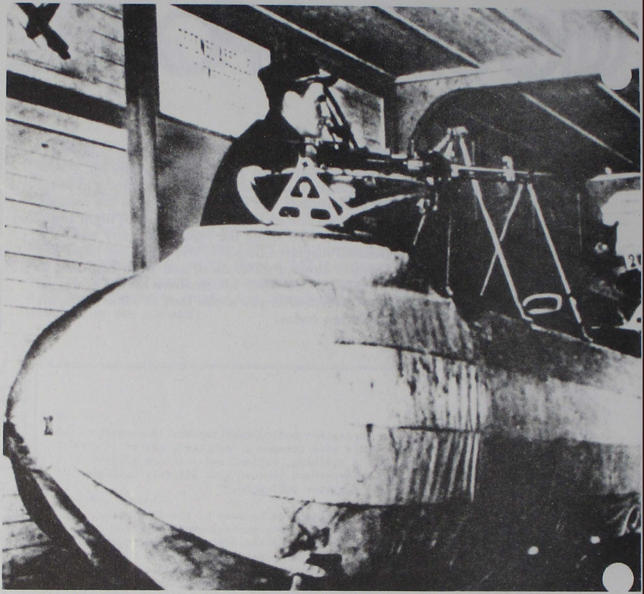
When the DIGEST editor sent me a copy of Colonel Bjorneby's letter, I knew I had found a fellow traveler. It's been nearly two years since I "hung it up" and moved from the world of flying to the world of engineering. However, those years from T-6s to F-15s (including F-86As, Es, and Fs) will hopefully never cease to be a yardstick as we strive to give you pilots the best possible fighters in the world from here at "Fighterland USA."

The colonel has struck a familiar note with his plea to tailor aircraft dynamic response to the instincts and reactions of the driver; and his perception of the problem indicates a lot of thought on his part. I would like to take a moment to share my view of what has taken place in jet fighter design across my years in the business.

To begin with, early jet fighters were essentially derivatives of World War II subsonic aircraft technologies. In short, flying qualities were dictated entirely by the aerodynamics of the system. The stability, control forces, pitch rates, roll rates, etc. were the direct result of the overall design, and, in many cases, were simply accepted as a fallout of design compromise. This approach could (and did) produce a series of aircraft types, one of which, as the result of a lot of design intuition and not a little luck, stood out as containing all the "good" things

(Continued on Page 74)

Simulation... (Cont'd)



Simulators are nothing new, as indicated by this WW I French aerial gunnery trainer.

the same way they would use the real world scene, and full proficiency is acquired rapidly. In other words, the pilot is to fly the simulator with exactly the same control inputs in the simulator as he would use in the air in the same circumstances. This may be a subtle but significant difference from the simulator flying techniques Colonel Bjorneby refers to.

It's also true that most trainers are strictly "Night - IFR" which is good for instrument training, some emergency procedures, and ADC-type intercepts but provides no help for tactical training in air-to-air combat and air-to-surface weapon delivery. It's no wonder fighter jocks aren't all that eager to log simulator time, and question the validity of simulation for any purpose! Still and all I must stick with that statement I made in the original DIGEST article, to the effect that today's simulators *can* and *do* lead and direct detail design of many aspects of the airplane. And I'd like to extend a personal invitation to you (and other "doubting Walters") to drop in on us when you are in St. Louis and observe first-hand how far simulators have come at MCAIR. If they still won't come up to your expectations, we need your help even more, because we've got an awful lot of money socked into these facilities, and even more importantly, we are making many decisions on handling qualities and weapon system design for tomorrow's aircraft with these simulators today.

Today's simulator technology provides the capability to make new trainers significantly superior to those of the past. Not only can we build airplanes that "fly just like the simulator" (MCAIR pilot Irv Burrow's comment after his first flight of the F-15), we can build simulators that fly like the airplanes they simulate! We can furnish the pilot with accurate air vehicle performance and a credible weapon employment environment - for example, raid penetration scenarios for radar intercept training; multiple aircraft visual air combat; and visual scenes for conventional and "smart" air-to-surface weapon delivery situations.

In addition, the trainers can automate the newest instructional techniques such as "instant replay" of an entire flight or selected mission segments for critique, with the trainee in the cockpit watching his mistakes or successes. Digital offline analysis programs can compare one trainee's performance to summaries of another's in the same scenarios and automatically "adapt" the next sortie to match the trainee's progress.

Perhaps the most serious problem that stands in the way of realizing the total training potential offered by simulator technology is a lack of current capability to identify and convert operational training requirements into realistic trainer hardware specifications. We in industry are aware of some of the current military efforts in solving this difficult problem; but progress has been slow due to the complex nature of the problem itself and impact on design and procurement costs.

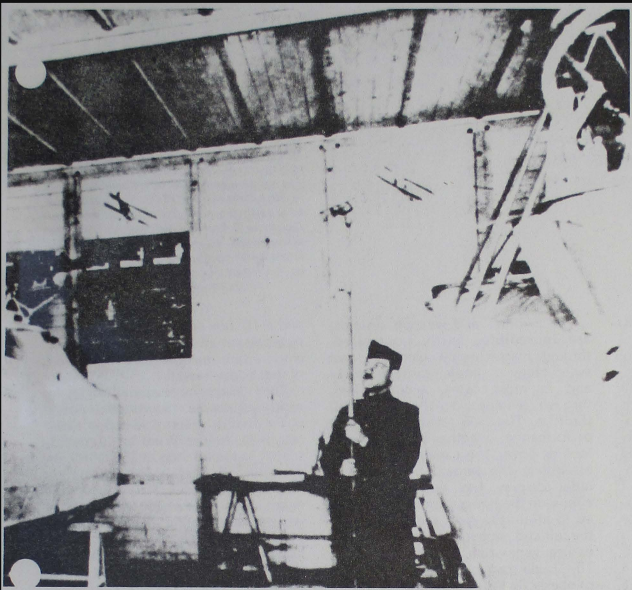
That's where inputs from people like you can help us both. Tell us what parts of the tactical mission need training emphasis most; and what cues are most important for these missions. What are the instructional techniques that IP's currently find most effective in teaching tactics? What information does the IP need in front of him for most effective instruction? Tell your training chain-of-command personnel what you need (and *don't* need) too, so that this information can be provided to the simulator program offices and reflected in current specifications.

As Pete Garrison has pointed out, Walt - we believe we *have* accomplished building airplanes that match the desires of the fighter pilot. And part of the simulation technology which helped design the F-15 has been applied to the design of flight training simulators to overcome some of the deficiencies of past trainers and become an effective part of the training program. In other words, we really think we've built both the simulators and the airplanes that you guys have got to have. Come on up and make us prove it!

Sabre... (Cont'd)

fighter pilots worship - the F-86 Sabre.

Then, as aircraft performance increased, "Mach One" reared its head. The aerodynamics of conventional control surfaces could no longer be "fed back" to the pilots because of the large shifts in pressure centers that created wildly variable control forces



Today, computers, visual displays, and optical techniques provide unsurpassed realism.

and pitching moments. As a result, "irreversible" hydraulic control systems were born. Remember the bar talk generated by the big difference between the F-86A with simple "boosted" ailerons and conventional horizontal tail and the F-86E/F with the "irreversible" systems?

We then plunged headlong into the "century series" airplanes. They got longer, heavier, faster; and the aerodynamics became more and more complicated as engineering frantically searched for clever designs that would allow pilots just to safely control these beasts, much less retain all those "good" handling qualities. Such things as pitch and yaw dampers began to appear as the short-period motion modes refused to behave in the manner of the slower, less dense machines. A proliferation of springs, bungees, and bellows began to replace all control surface feedback to the pilot. Mechanical advantage shifters, ratio changers, and aileron/rudder interconnects became the vogue. Inherent aerodynamic flying qualities became the victim of the quest for more and more speed at higher and higher altitudes.

I have a feeling that this is about the place in aviation history that Colonel Bjorneby finds himself. With the introduction of fighters like the F-15, I really believe that there is a new chapter being written in our search for maneuverability as well as speed/altitude performance. Docile but responsive flying qualities are a must in the close-in combat areas we must once again address. I think we have indeed accomplished what Walt has so perceptively pointed out, i.e., created an aircraft that *does* match the desires of the pilot to the capabilities of the machine.

Utilization of high authority fly-by-wire and/or control augmentation systems (CAS) with the attendant control laws has allowed us to harness the very powerful flight control surface requirements that are necessary to give the pilot the kind of aircraft response he demands throughout the flight envelope. Development of these control laws requires that a high-fidelity model of the air vehicle aerodynamic characteristics be married to an equally high-fidelity manned digital simulation in order to determine the flight control mechanization required to produce the proper aircraft motion commanded by the pilot. That's where Larry Ross and his fellow electron-benders enter the picture. Colonel Bjorneby expresses concern about two primary problems in his letter - today's simulator and tomorrow's airplane. I've just told you a little about where we think we stand from the airplane side, and Larry is responding from the simulator point of view, but let me cite one personal example of what "flight simulation" can do if well done.

I flew the MCAIR portions of the USAF Time-to-Climb ("Streak Eagle") record program - some 30 or so flights for profile and system verification. I also "flew" the MACS (Manned Air Combat Simulator) portion of the program, wherein we evaluated planned techniques from a time, flyability, and pilot workload standpoint. Since the express purpose of the "Streaker" was to do what no F-15 had ever done before, we were obviously going to have to push state of the art capabilities in every aspect of the project, flight simulation included. How did we fare?

First off, merely scheduling simulator requirements into the program itself is an indication of the confidence we have in those big boxes. There were many things to accomplish before Majors Macfarlane, Petersen, and Smith exploded out of Grand Forks Air Force Base a couple years ago. Everything in that compressed program had to pay its own way; and we certainly got our money's worth out of "MACS." Aircraft handling qualities going "over the top" at 100,000 feet and 40 knots of indicated airspeed were as predicted by the simulator. Building up to that high profile without the benefit of the simulator would have taken a great deal more time and money. The experience we gained flying the simulator greatly reduced the amount of practice flying that would have otherwise been required.

Walt, I don't know if you've had the opportunity to fly the Eagle, but I'll make a guess that it's still in your future. I draw that conclusion from your letter and from my own reactions when I first had the privilege of flying it. For me, it really was a return to the "cow pony" days we both remember with pleasure. With the F-15 on the street and the F-18 waiting in the wings, I feel that we've taken a good shot at addressing your concerns. Thanks for the letter and the opportunity to philosophize with you - let us know how you like the Eagle - "The Sabre of the Seventies." ■

Over the past six years,
lot's of good words have been written
on the Eagle by the "Old Pro's."
But how about the newer guys? Here are . . . .

Some Personal

(1978)

By LARRY WALKER
Experimental Test Pilot

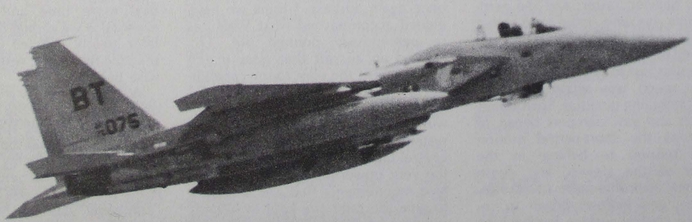
Four years ago, one of the "oldest pro's" in the business - Major General Gordon Blood, then commander of Tactical Fighter Weapons Center at Nellis AFB wrote a letter to Mr. George Graff, president of McDonnell Aircraft Company. He was commenting on his first flight in the F-15 - ". . . I feel I could have easily flown the first ride solo. I believe the young fighter jock will eagerly learn the systems and safely fly and maneuver the aircraft with control augmentation as long as he has some fighter time behind him for

At the time of my arrival at MCAIR, I had had a good amount of experience with flying qualities and performance testing of numerous airplanes, including modern fighters, but I felt that I was one or two generations behind in knowledge of avionic systems. The F-4 had been a fairly difficult airplane for me to learn, and the F-15, with its advanced systems, would probably take a year or more, I feared. However, to my delight, hands-on experience coupled with references to systems descriptions, has made the Eagle a dream to fly and learn. In fact, after six training and familiarization flights, I commenced production flight testing of those F-15s that had already flown first airworthiness flights. Then after 27 hours in the airplane, I commenced first flight airworthiness testing as well.

The avionics and weapon systems are incredible. Easily controlled through master mode selections, the switchology is simple, easily learned, and in most cases, accomplished through switches on the stick and throttles. The F-15 radar has superb performance - whether looking up or looking down, the capability remains essentially the same. The synthetic radar display has done much to eliminate the hours of practice required to attain the right radar gains for the salt and pepper effect needed with earlier generation weapon systems. The Eagle radar display shows the pilot exactly the altitudes he is searching; shows target information during lock-on - aspect, G, speed, and altitude; and also has a transponder interrogation feature. A head-up display with weapon system information and a TD box superimposed over the target ties it all together with the real world - sure makes visual acquisition of that bogey easy!

The F-15 can be nearly all things to nearly all people - sports car, luxury, or top fuel dragster; it is happy slow, fast, high, or low. Want to do a stick snatch to the aft stop at 200 KCAS, or straight and level at 100 KCAS, or maybe a tailslide? How about an entire loop below 200 KCAS or a vertical accelerating climb? Maybe a level acceleration from 300 to 500 KCAS in 8.5 seconds at an acceleration rate of 1.6 G, or dash to Mach 2.4 at the speed of heat? On the other hand, strap on three external tanks and cruise subsonically for nearly five hours, or at M 1.6 if you're in a hurry.

I could go on, but I'd rather fly than talk, and another Eagle is ready to go!



Opinions on Eagle Driving

basic maneuvering . . ." He went on to some other complimentary opinions on the Eagle, but it was his reference to the "young fighter jock" that is of interest here. If you fit that classification, how eagerly do you figure you can "learn the (F-15) systems?" For an opinion from within our own Flight Test organization, we turned to the two newest MCAIR test pilots. If you are a lieutenant or captain going directly into Eagles, they'd like to hear how your experiences compare with theirs - write to them c/o the DIGEST.

By JACK JACKSON
Engineering Test Pilot

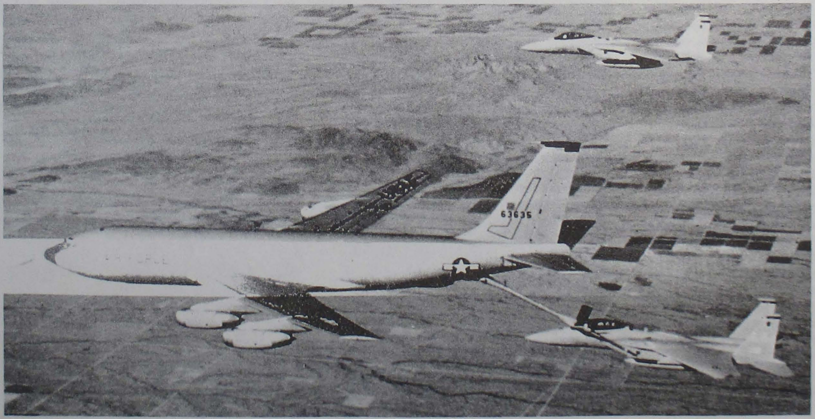
Having just checked out of the military (USMC) and into the civilian world (MCAIR), I have been doing a lot of listening and learning about McDonnell products. As the newest test pilot for the company (5 months), I recently had the privilege of checking out in the Air Force's newest fighter - the F-15. Because there are a lot of new guys like me in the USAF, there may be some interest in this "new guy's" opinion on this machine.

Unequivocably, the F-15 Eagle is the easiest and safest aircraft I have ever learned to fly.

To me, the design and engineering that have gone into this aircraft are amazing. Although I've only begun to scratch the surface of everything in it, it is readily apparent that the primary pilot emphasis and attention is on the weapon system. The F-15 was designed so that the majority of the pilot's time can be devoted to the weapon system and not to worrying about actually flying the airplane. The ease and comfort with which the Eagle handles makes it a dream to learn to fly . . . and to be flown well I might add, essentially from the first flight on. I certainly agree with the feeling expressed by some foreign Eagle pilots who, after a couple hundred flight hours, looked back on their initial experiences with the airplane - they felt they were just as effective at flying to the edges of the envelope after two hours as after 200.

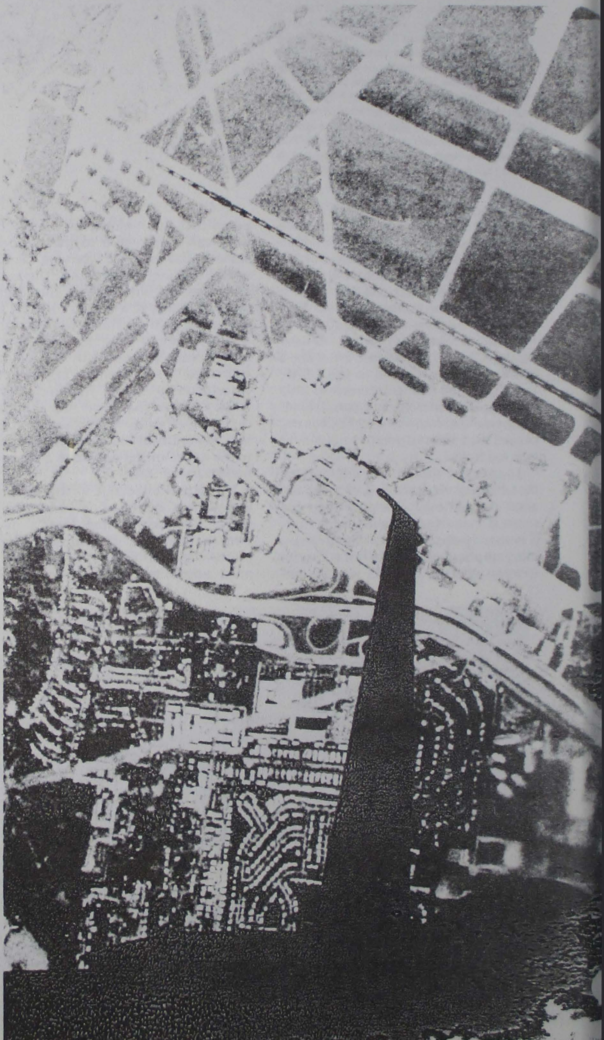
My actual checkout in the aircraft was rather anticlimatic. Like most young aviators starting into a new bird, anticipation and anxiety were pretty high. After the first flight, I must admit to something of a letdown - all the things I had expected to be difficult simply were not. Max performance takeoffs, stalls, acrobatics, and landings were extremely easy. I found it to be a very honest airplane with respect to control inputs and its inability to get into trouble because of departure resistance (it's the only high performance aircraft I know of without AOA limits). Its quick response to thrust inputs makes such things as aerial refueling routine. Cockpit simplicity contributes to a low pilot workload - with such features as an automatic fuel system; HUD with velocity vector for IFR flying; shallow trim gradient; no limitations on throttle movement; and no maneuvering slats or high-lift devices to operate.

While I may be the newest guy here at MCAIR, I already feel very comfortable in the Eagle. I think you will too!



(1978)

Viking Departure...



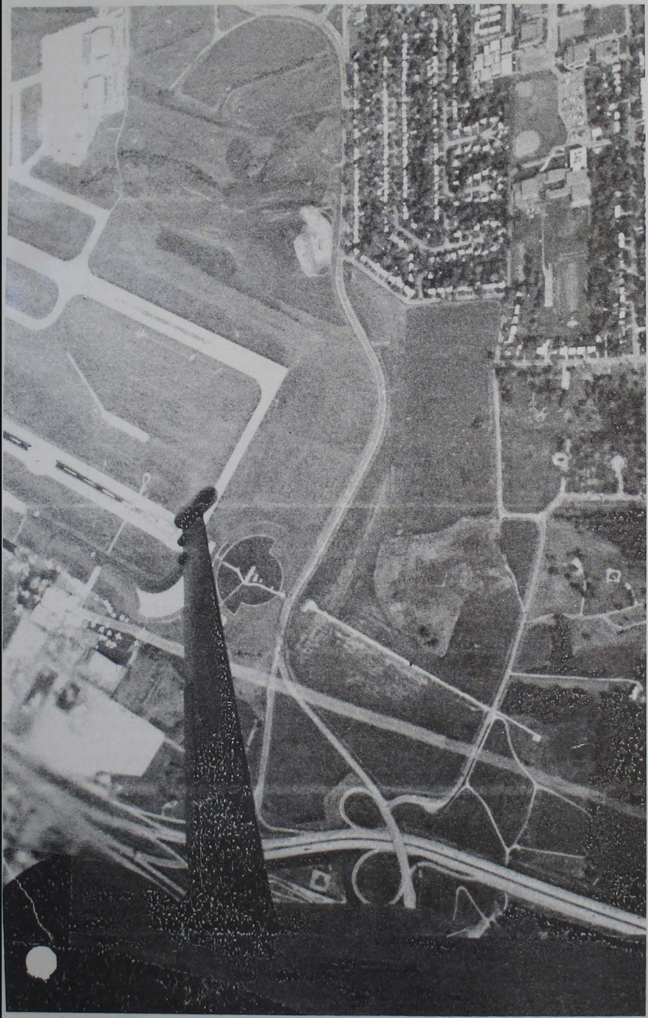
Two issues ago, our front cover showed a dramatic photo that several people have asked to learn more about — they were wondering just exactly what was going on in the picture that we're reproducing here again. The shot captures a "Viking Departure" — an accelerated takeoff and climbout that has recently become standard operating procedure for MCAIR test pilots and the F-15 Eagle. However, while it looks "air-show" (and according to the pilots is lots of fun to do), this procedure is really all business and makes sense for several reasons.

This photograph was taken by company test pilot Denny Behm from the back seat of an F-15B, while front-seater Pat Henry, MCAIR's chief experimental test pilot, executes the Viking Departure maneuver from Lambert-St. Louis International Airport runway 12R. Are you wondering how Denny managed to snap this super picture, during a five mile-per-minute climbout? When asked how he managed to frame part of the airport terminal between the twin tails of the Eagle, Denny replied humorously, "framing the picture was easy — once I learned to sit backwards in the seat!" The truth of the matter is that the photo was not planned — it just sort of happened that way. Actually, only the camera was "backward" — Denny himself was facing forward and strapped in the seat normally. While holding the camera (Hasselblad 2¼ x 2¼ with a 38MM lens) in an awkward position above the seat's headrest, he snapped a quick series of photos. Only after the film was developed did Denny realize that he had successfully photographed the airport, and not the canopy rail or the back of his helmet. It doesn't really matter what lucky mechanics were involved in the process — the end result was obviously just great.

A max-effort, straightup, climbout maneuver from field elevation to 8500 feet in approximately 20 seconds from brake release, and within five nautical miles from the departure end of the runway isn't usually executed at a commercial airport. Does this mean that the FAA has relaxed the flight

Aviation Safeguard

By BOB McATEER/*Product Service Specialist*



rules which have helped Lambert-St. Louis Airport maintain a top safety record? Not in the slightest; a Viking Departure requires continual coordination and highly professional skills by both the pilots and the FAA air traffic controllers. (We might add that it also requires a high-performance jet aircraft capable of operating within the tight performance limitations established for the maneuver!)

A Viking Departure is controlled very closely by the FAA from the control tower "cab". A pilot must request this departure prior to leaving the MCAIR flight ramp, and only when Visual Flight Rules prevail. After receiving the requested clearance, the pilot may proceed only as directed by the FAA air traffic controller. As a result, a Viking Departure adds new dimension to aviation safety and operating efficiency for both St. Louis FAA air traffic control and MCAIR.

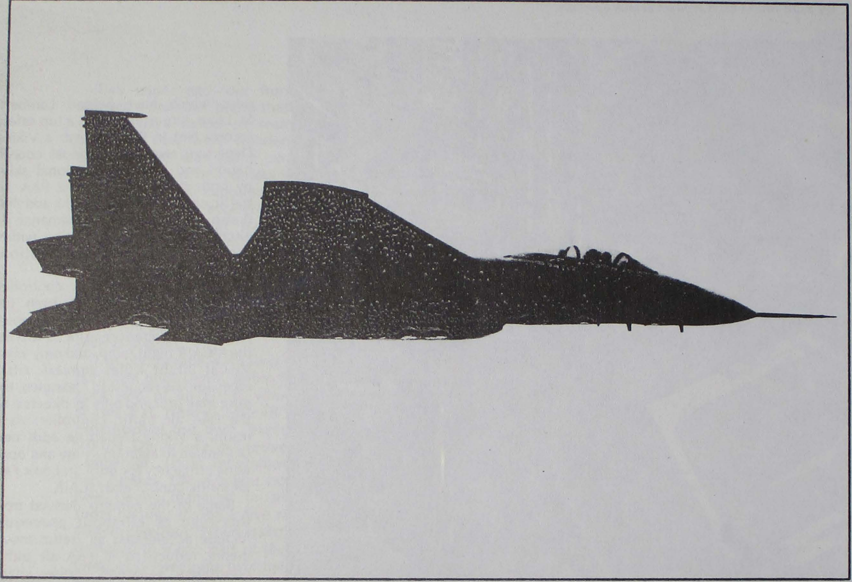
Some of the benefits derived from this type of climbout procedure include accelerated air traffic movements, reductions in FAA air traffic controllers workload, noise abatement, pilot's radio workload minimized by remaining on tower frequency throughout climbout, and minimal exposure of high performance jet fighter aircraft to other airport traffic. An accelerated takeoff and climbout are also extremely important to MCAIR operations because of fuel savings, which gives the pilot more time to perform his flight test mission.

How does the code-name "Viking" tie-in with this maneuver? As the story goes, one of the controllers in the tower had just finished reading an article about the Viking I spacecraft blastoff on its mission to Mars, and seeing the first F-15 expedited climbout, he remarked, "that looks like a Viking I liftoff!" Since the procedure had not then been given an official tower identification, and the word "Viking" was short and easy to pronounce, it immediately caught on with both pilots and controllers.

So, when you see a "Viking Departure" you will know that the pilot, even though he is enjoying every second of it, is making a max-effort climbout beneficial to everyone. ■

USAF 10280 "EAGLE ONE"...

(1981)



First flight of F-15 occurred on 27 July 1972 at Edwards AFB, California. No longer flyable, this airplane is now the feature attraction of a traveling USAF exhibit on American air power. (Actual USAF S/N is 71-280, but aircraft is exhibited with original tail number for historical accuracy.)

Various fates befall military fighter airplanes when they have "served their time." Most are quietly retired to preservation depots to await possible emergency recall in the future. Some, if too severely battered, are unceremoniously cut up into small pieces and fed to the recycling machine. Others may be internal catastrophes but still look good enough on the outside to become base "souvenirs" of an earlier era. And a few - a very few - while permanently grounded, continue on distinguished full-time "recruiting" duty. F-4C Phantom 64-0683 was the first MCAIR model to serve as a public symbol of USAF air power; here is the interesting story of how our F-15 Eagle 10280 became the second . . .

When USAF 10280 - "EAGLE ONE" rolled off the MCAIR final assembly line in St. Louis back in 1972, it was the prototype of what was to become the world's best air superiority fighter. Between 1972 and 1975, it proved the design and demonstrated the capabilities of all the F-15s to follow. While its flight career was relatively short - 432 flight hours in 534 test flights - USAF 10280 played an important role in development of the weapon system. In addition to being the first flight article, it opened and expanded the F-15 flight envelope; evaluated flutter, stability, and control performance; calibrated the pilot systems. However when the time came to consider reconfiguring F-15 No. 1 for combat or training functions, its pre-production configuration ruled against it - many of its parts were not standardized, and field maintenance of such a peculiar bird would be too difficult. Despite its history-making past, 10280's future looked bleak, until "AFOG" entered the picture.

The Air Force Orientation Group (AFOG) at Wright-Patterson AFB, Ohio, was awarded custody of the airplane, with the directive to turn it into a non-flying public display vehicle. It would henceforth serve only "on the ground," but was destined to become probably the best-known and most-seen Eagle of them all. Perhaps a hundred pilots actually settled themselves into the cockpit of 10280 for flight, but millions of people around the United States have climbed a short flight of steps to peer into that same cockpit for a close-up look at a real fighter jet. Today, the F-15 is the backbone of the Tactical Air Command's fighter force; and EAGLE ONE provides the American public a first-hand view of that force. However, it was not an easy task, making this high-performance aircraft safe and suitable for public exhibit.

The first obstacle was how to prepare this F-15 for display. The AFOG

FROM SKYWAY TO HIGHWAY!

crew spent almost ten months modifying the aircraft for its public "premier," including gutting the interior of engines, electronics gear, testing sensors, and other reusable pieces of equipment to reduce weight and save money.

Next, work needed to be done to make F-15 No. 1 appear generally similar to current combat versions. AFOG's airplane now sports one of each style afterburner used on F-15s. In addition, because EAGLE ONE was not used in the weapons testing program, there was no 20mm gatling gun installed so a gun fairing had to be added. The viewing public not only sees these additions but also patches and "non-standard" pieces of equipment that testify to the aircraft's research and development career.

Together with display preparation, the problem of moving the aircraft from place to place had to be considered. Two 50-foot flatbed trailers were specially designed and built for the F-15 exhibit. One trailer carries the wings and the 4,000 pound crane used to attach and remove the wings, stabilizers, and radome on the fuselage. The second trailer carries the fuselage itself.

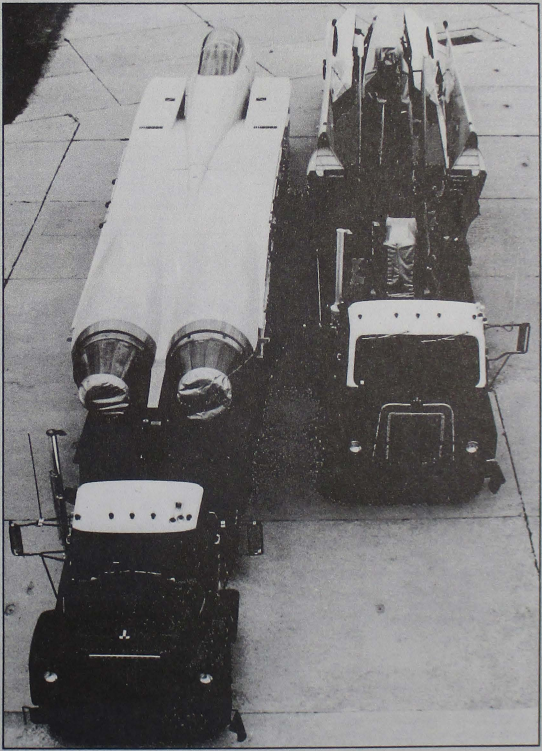
Once the 20,000 pound exhibit arrives at its destination, it takes about 18 hours to ready the aircraft for visitors. Crewmen assemble one side of the plane and then move to the other side. Rear and front fairing panels are attached first to the fuselage. The crane is used to get one wing at a time off the trailer and placed on the ground. The crane cable is removed, the wing is turned to the proper position, and the cable reattached. The wing is then lifted and fitted to the plane.

Jacks placed under the wings lift the fuselage off the trailer. The trailer is then moved forward and the main landing gear is lowered and secured into position. After the weight of the aircraft is on the main gear, a jack is moved to the front to raise the nose of the plane off the trailer. The trailer is then moved completely out from under the plane and the nose gear is lowered and locked. Afterwards, the crane is again needed - this time to affix the radome to the aircraft nose. The final steps in readying the exhibit include attaching panels, assembling the viewing platform, placing display signs, and the cleaning the entire aircraft.

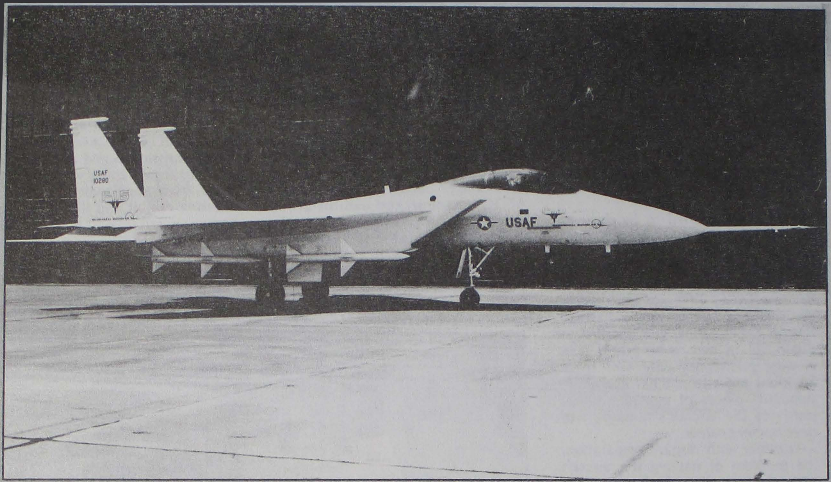
During the tour season (generally the summer months), the AFOG crew repeats the setup steps at every stop. Each time EAGLE ONE stands display, AFOG's handpicked exhibit group proves that they can routinely do the impossible - taking their F-15 wherever interested people want to learn more about aviation, airpower, and the US Air Force. Does AFOG feel that all this effort is worthwhile? Definitely, and so does the rest of the Air Force.

The AFOG display crew tells visitors about the F-15's history and its important part in the Air Force's national defense mission. Some of the display crew are among those who converted 10280 from supersonic test bed to traveling exhibit and the immaculate display aircraft reflects their pride and hard work.

Approximately seven million people a year learn about the Air Force and aviation through AFOG exhibits. According to Colonel Arthur F. Creighton, Jr., group commander, "No other Air



When partially disassembled for over-the-road transport, F-15 No. 1 requires two specially-designed trailers. Assembly at exhibit site takes 18 hours. ▶



Force public affairs tool allows the service to go one-on-one with as many people as AFOG's exhibits."

"EAGLE ONE" - the first F-15 - has, in its second career, proven to be one of AFOG's most popular and effective displays. Thus America's number one (and proudest) Eagle is still making a name for itself and will be enjoying a pleasant semi-retirement for many years to come. Keep an eye on the highway; you may soon see the "Over the Road Eagle" coming your way.

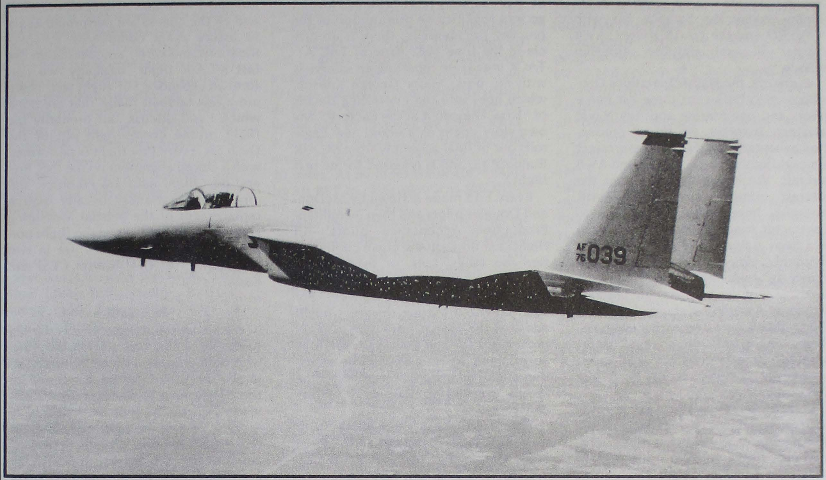
One of the individuals most interested in the second career of F-15 No. 1 is "Eagle Driver No. 1" - Irv Burrows. The picture which opens this article was taken during the first flight of this first Eagle, and Mr. Burrows is the pilot in the cockpit. Today, he is Director of Support Programs here at MCAIR, but back then he was our Chief Test Pilot, and he remembers vividly the 27th of July, 1972 . . .

"That first flight was the culmination of a lot of preparation by a lot of people. My own involvement started several years before and included many hours in design meetings, planning conferences, simulator sessions, and flights in other aircraft. Although such extensive preparation removed a lot of the "mystery" of that first event, it certainly didn't diminish the pride and satisfaction I felt as soon as we were up and away, and I knew we had a great airplane! That was a moment to savor - a time for a test pilot to think to himself that . . ."This is what it's all about"!

Nine years and thousands upon thousands of both air and ground miles separate these two photographs of the same airplane. Picture above was taken of F-15 No. 1 after conclusion of ceremonies surrounding rollout of this first Eagle at St. Louis factory on 26 June 1972. Scene below took place in New York City in mid-summer of 1981, where "EAGLE ONE" was on display in Manhattan's Battery Park.

"The Eagle on the trailer is like an old friend to me; in fact, its original name plate is attached to a plaque hanging on my office wall! It was a good test airplane and the recipient of a lot of tender loving care (plus a lot of design modifications). USAF 10280 took us to a lot of brand new conditions as the F-15 flight envelope was extended. I think it's just great that this airplane which has seen over 800 knots on the deck, close to 2.5 Mach at altitude, and paved the way for our operational F-15 fleet can now be viewed and touched by the general public. I'm looking forward to seeing "EAGLE ONE" again somewhere soon, myself"! ■

newly manufactured fighter aircraft receive stringent checks during... (1982)



Military Acceptance Flight Testing

By CAPTAIN DAN LOHMEYER, USAF/*Production Acceptance Pilot-Flight Operations Division, NAVPRO/St. Louis (McDonnell Douglas Corporation)*

Several years ago, the DIGEST published an article by Dee Francis, MCAIR Chief Production Test Pilot, describing the procedures followed by company aircrews in checking out newly manufactured fighter airplanes. When our company pilots okay an airplane, it is then turned over to the government for "acceptance tests." Government acceptance test flying is performed by a group of military pilots assigned to the St. Louis plant, as a part of the NAVPRO — Navy Plant Representative's Office. As a sequel of sorts to Dee's discussion from the company point of view, this article, written by one of the NAVPRO pilots, looks at the military's responsibilities in getting a new Eagle, Hornet, or Harrier on its way to you. Captain Lohmeyer describes some of the things the government aircrews are looking for when they check out a newly-minted MCAIR fighter.

A 1972 graduate of US Air Force Academy, Captain Lohmeyer has flown F-4D/E Phantoms at RAF Lakenheath, England and Clark AB, the Philippines. Now a Production Acceptance Pilot with NAVPRO/St. Louis, he has flown the F-15 since 1979, and will begin an EWI (Education With Industry) assignment with McDonnell Douglas Corporation in September.

US government contract management personnel have been working in St. Louis with McDonnell products since the early 1940's. The US Navy was basically in charge of activities for the first three decades, but in 1971 the US Air Force Contract Management Division (AFCMD) of Air Force Systems Command was charged with all contract and subcontract, quality assurance, pricing, production, and program management administration dealing with government contracts at the St. Louis facility. In military jargon, the function was known as the "AFPRO," for Air Force Plant Representative's Office. On 7 March 1982, the Naval Air Systems Command formally accepted responsibility for all plant cognizance, including flight test of all production aircraft. Now the jargon identifies us as "NAVPRO," for obvious reasons. These changes in contract management responsibility take place as a function of the balance of contracts McDonnell Douglas Corporation has with the Air Force and the Navy. For over ten years, the USAF F-15 tipped the scale toward AFPRO responsibility; today the balance lies with NAVPRO and the F/A-18 Hornet, AV-8 Harrier II, and Harpoon anti-ship missile.

Currently, the Flight Operations Division of NAVPRO uses three Air Force pilots and one Marine and five Naval aviators. Together, we fly all production acceptance (FCF) and chase/target support flights in F-15, F/A-18, and AV-8 aircraft. We basically insure that the aircraft coming from the MCAIR assembly lines not only conform to contractor specifications but are also in a form usable to the fighter pilot "in the field." This may mean changing or clarifying performance specifications to insure that the best possible product arrives at Langley, Bitburg, Lemoore, Cherry Point, or wherever. For example, there were significant changes incorporated in the original F-15 PSP tapes before we would accept them for delivery.

In addition to production acceptance flying, pilots assigned to NAVPRO perform various other functions. The Air Force pilots perform most normal additional duties associated with a flying unit, such as safety, training, scheduling, and standardization and evaluation. Other duties involved in government contract administration take up the rest of our time. Four of the current Naval aviators are Aeronautical Engineering Duty Officers (AEDO) and perform primary duties involving program management of the Eagle, Hornet, and Harrier programs. AEDO's are both managers (much like the USAF rated supplement) and flyers. It is a function unique to the Navy and has the interesting benefit of having the program manager actually flying the particular weapons system he manages. That keeps him familiar with current production aircraft and gives him a "hands-on" knowledge of recent problems.

F-15 ACCEPTANCE PROGRAM

Now let's turn to the F-15 as an example of the nuts and bolts process of getting you an airplane to fly. In the nine years that MCAIR has been producing Eagles for USAF (and a few other Air Forces), more than 700 A/B/C/D models have gone over the fence to you, and every one of them has received the acceptance test program described herein. If takes nine full months of production from the time the first bulkhead is laid until an F-15 is delivered. That does not include long lead times required for such items as titanium forgings, which have been as long as 24 to 36 months. The assembly line is fascinating and should be seen by every military pilot, although I won't go into specifics on that portion of the process. (Incidentally, there is an article in the June 1982 issue of TAC ATTACK magazine reporting an interview with my boss, Major George Knirsch, which goes into the interesting details of "How They do it at the Factory." My own story opens as a brand new Eagle rolls out of final assembly from MCAIR Building 45, and is released for its first flight.)

Every F-15 made is flown by McDonnell Douglas pilots and then by military Production Acceptance pilots. All flights are flown in the clean configuration (no tanks, rails, or pylons), and each aircraft gets about four flights, on the average, prior to its delivery. For you Navy and Marine drivers, I might add that the profile I describe also approximates the one flown during F/A-18 acceptance flights, and with the exception of the radar work approximates the profile that will be flown in AV-8B acceptance.

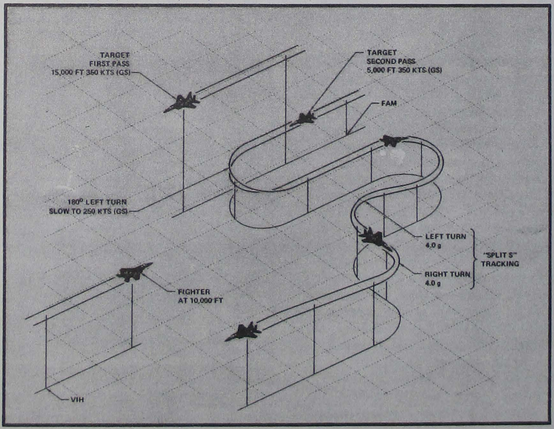
The first flight is used primarily to speed run the airplane and perform any other checks that fuel remaining permits. The speed run, performed by MCAIR pilots on every F-15 (and by military pilots on every fifth F-15), takes the airplane to 710 KEAS. This checks not only for 1.4 Mach EEC lock, but also for any panels that may buzz, a rudder limiter that may not work, or a bypass door that may not schedule as it should. The second flight re-checks any previously squawked items and completes remaining checks that fuel considerations didn't allow on the first flight.

The aircraft is then turned over to the pilots in Military Flight Operations, and all the checks are performed again to assure exact compliance to specifications and verify any fixes from the last MCAIR flight. Basically, we perform an expanded FCF flight test. There are a few oddball things that are done which I will discuss, but primarily the flight profile comes right out of the Dash Six. Every first flight is performed with a stored alignment on the INS. Pre- and post-flight data are recorded and any drastic variances usually require replacement of the Inertial Measuring Unit and a reflight. As to the flight portions, the real differences are in two systems — Jet Fuel Starter (JFS) and Radar.

JFS CHECKS

We install the jumper wire in the JFS to enable our starting it, while airborne, with both engines running. It must start in two out of two, or three out of four tries. Therefore, to perform acceptably it must start in both of the first two attempts. Failure to light on either of those two requires that it start successfully on the third and fourth attempts to pass the test. Failure to meet these criteria requires a JFS change and a reflight. We usually make one start in the 15,000 to 20,000 foot altitude block, and one start between 20,000 and 25,000 (an approved test envelope for St. Louis flights). Starts are usually attempted at around 220 KEAS.

We also shut down an engine and start it with the JFS. Actual procedures



Typical radar profile flown during F-15 government acceptance tests.

vary with individual pilot technique, but generally we all follow the same sequence. After the JFS is started, the right engine is shut down. I personally let the engine wind down to 0% N_2 for a couple of reasons. First, after insuring that the left hand generator will carry the load and that the JFS has started, I have a controlled situation in which I can check for proper operation of the switching valves under airloads. Second, the 0% N_2 situation provides the most severe power extraction situation for the JFS since it must not only turn the engine but also counter the effect of airloads on the fan.

RADAR CHECKS

The other major portion of the profile involves checking the radar. That portion takes from twenty to forty minutes, and we always task a dedicated target against every first flight of the Eagle. That target may be one of the chase/target aircraft assigned here at McDonnell Douglas or another production aircraft if one happens to be flying about the same time. The sketch on page 23 illustrates the orientation of the profile.

The target and fighter are separated by 100 miles to start the pass. The look-up pass is used simply to check detection ranges and operation of the AAI for all modes and codes. We usually check radar detection in channels 1, 3, and 5 during the look-up portion, then have the target descend to the lower altitude for the look-down phase. The look-up portion is usually completed with target and fighter still about 60 miles apart. During the look-down phase we check the remaining channels, and usually check velocity search in two of those channels. When the target gets to 40 miles, we check RAM-A and RAM displays and tracking, and revert to normal single target track by 30 miles. At 30 miles we begin looking for HI PRF track to switch to MEDIUM by about 22-23 miles.

After PRF switch (which gives an indication of the signal-to-noise sensed by the radar), we have the target turn and test the tail-on look-down detection at 20-25 miles. With that complete the target turns head-on again, and at R max_1 a simulated AIM-7 launch is accomplished. The target then does a climbing "Split-S" maneuver to insure that the radar can track a moderate escape maneuver and to bring the target to the fighter's altitude. We then check for proper operation of all of the auto lock-on modes (VS, BS, SS) with the target in a 2-3G turn, both into and away from the fighter. Additionally, all HUD steering cues for MRM, SRM, Guns, and VI are checked to minimum range. Any anomalies, especially weak detection or strange programming/indications, are squawked and reflown. Additionally, any major component change subsequent to a successful radar run requires another radar flight.

On each flight we have a preprogrammed Armament Control Set (ACS) and several IP's and targets programmed into the central computer. All of this allows us to check all of the air-to-ground weapons systems and HUD cues (short of actually dropping something off of the aircraft). We check CDIP, AUTO, DIRECT, and make simulated "blind-bombing" runs on a show IP and target using the Doppler Beam Sharpening (DBS) mode of the radar. As an aside, the ground mapping features of the F-15 radar have undergone considerable improvements during my tour here, and more appear to be on the way.

That's it. As you can see, we check everything to insure the best possible product. That's basically our job and the job of all the people in NAVPRO/St. Louis — to insure that the fighter and attack aircraft that reach the user are of the highest quality and lowest cost possible. If this discussion has aroused some curiosity or a question, don't hesitate to call us at Autovon 693-6444/6231. If Flight Ops can't answer the question, we'll put you in touch with the person who can. ■

"Additional Duty." Captain Lohmeyer displayed the F-15 for thousands of spectators attending recent Open House at Scott AFB, Illinois - home of Military Airlift Command. The production Eagle was made available for close-up viewing by eager visitors along with giant MAC airlifters and hospital aircraft. Here, in what may be a "long-range" recruiting session, the captain relaxes with one of the many young people he talked to during the static display period. (USAF Photo by SSgt Annette Ware)

product support digest

Covers: (outside front) MCAIR artist Chuck Wood's painting shows scenes associated with USAF F-4 62-12200 and Air Force Museum at Wright-Patterson AFB, Ohio. (inside front) Pilot's eye photo of F-15 Head-Up Display at instant of "attack solution." (outside back) Army helicopter and F-4 during airlift from St. Louis to AF Museum at Dayton.

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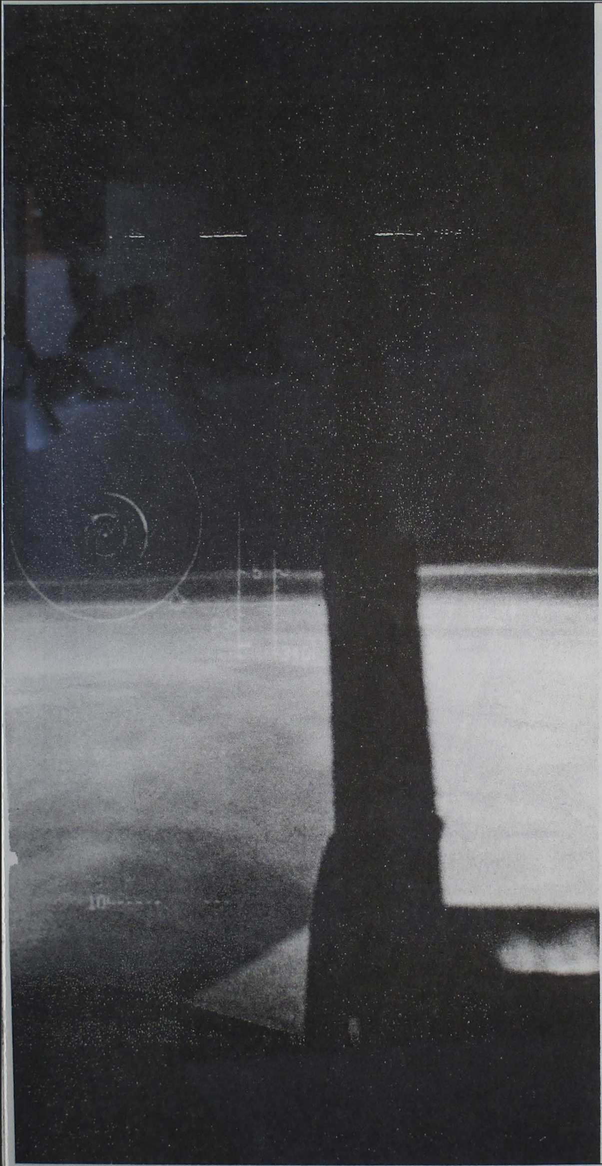


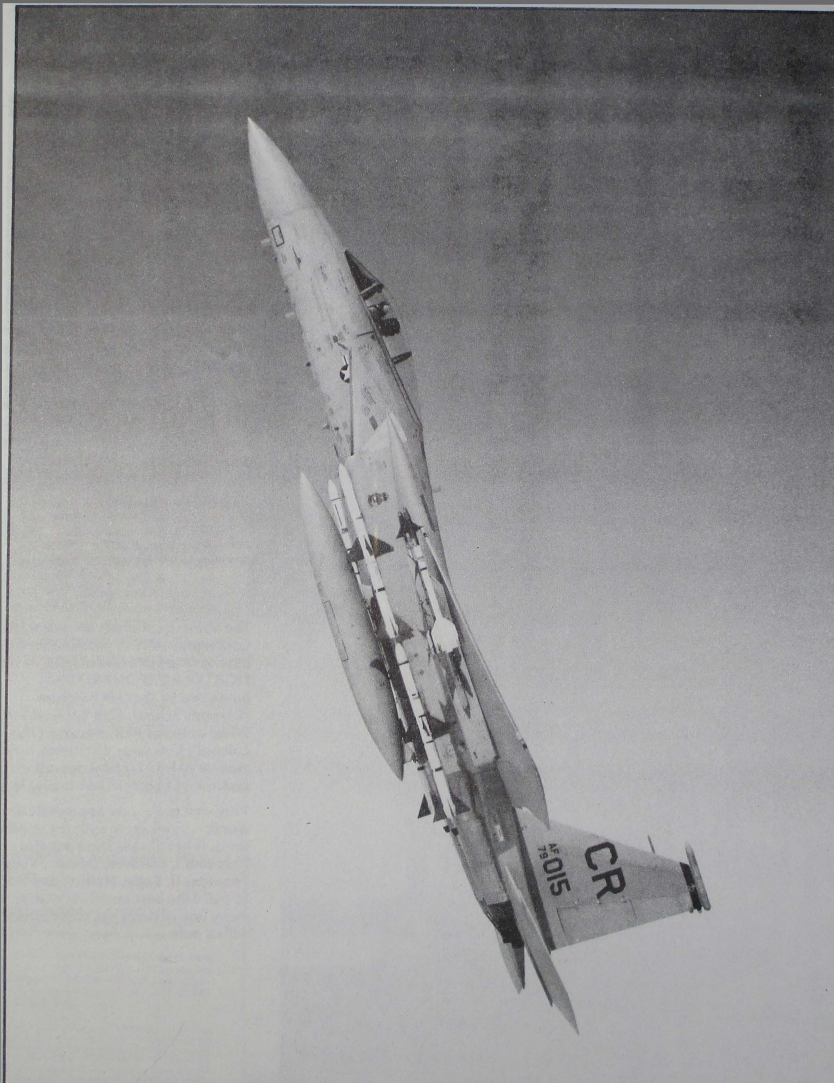
Granted, McDonnell-Douglas builds great airplanes, but men win wars.

With its great thrust and low-wing loading, state-of-the-art avionics and munitions, excellent visibility and near flawless handling qualities, the F-15 Eagle is indeed an imposing figure in the air-to-air arena. Its superior qualities could combine to provide the "edge" needed for victory over lesser aircraft to even the mediocre fighter pilot. Such casual abuse of this fighter's potential would smack of criminal negligence and must not be tolerated. As has been said before: "The crate is not nearly as important as the man with his hand on the pole."

Lt. Colonel Philip W. Handley
Director, Stan Eval, USAFE
Ramstein AB, Germany

The above quotations are extracted (and reprinted with permission) from a letter printed in a recent issue of the FIGHTER WEAPONS REVIEW, published by the USAF Fighter Weapons School, 57th Tactical Training Wing, at Nellis AFB, Nevada. (The colonel's letter was discussing various aspects of F-15 tactical operations in a classified document not available to us.)

Very well put . . . we appreciate the words . . . and agree with the implications. It has always been our aim - Phantom I, Banshee, Demon, Voodoo, Phantom II, Eagle, Harrier, and Hornet - to build the best possible "crates." But every one of them has come equipped with a pole.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